H I G H W A Y L O C A T I O N

A THESIS

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B y

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OUTLINE OF THESIS

I. Introduction

- 1. Historical
- 2. Purpose of this Thesis

II. Economics

- 1. Factors Involved
  - a. Traffic Census
    - 1. Object
    - 2. Principles and Method
    - 3. Equipment
  - b. Service and Cost
  - c. Effect of Grades and Curves
- 2. Safety
- 3. Right of Way

III. Location

- 1. General Considerations
  - a. Basic Principles
  - b. Requirements or Recommendations
- 2. General Requirements
  - a. State and Federal Specifications
  - b. Accepted Practice
  - c. Drainage Structures
- 3. The Survey
  - a. Organization of the Party
  - b. Classification of Survey
  - c. Conduct of Survey
    - 1. Methods
    - 2. Notes

3. Field Preparation of Data

4. Bridge Location

a. Field Procedure

b. Requirements

5. Railroad Grade Separations

a. Requirements

IV. Office Procedure

V. Conclusions

VI. Bibliography

FIG. I

View along Center-Line of Location

Thru Brier Creek Swamp

Burke County

Waynesboro - Augusta Road

Georgia State Route 21

I N T R O D U C T I O N

INTRODUCTION

When this nation was founded its transportation problem was a simple one. Water transportation was virtually its only means of communication; hence the determining elements in the location of towns and colonial industrial development were nearby rivers and lakes. What few roads were available were poorly constructed, in fact were merely trails at first, and were always impassable for many months in the year. The vehicles for travel were so uncomfortable that people and products were sent by boat whenever possible. Where there was no water transportation, canals were projected and frequently constructed, for no one had yet visioned the "iron horse."

With the coming of the "iron horse," snorting down a short mileage of track, progress would not be delayed and the nation, states, and even local communities loaded down railroad projectors with bounties almost unlimited in character.

By this time a very limited mileage of our roads had been improved by the use of first plank then crushed rock, cement and bitumen. It is to be noted that the early improvement of our roads came by widening paths to trails for mounted men, thence widening these trails to accommodate the wagon and stage coach. It was these later that were improved, not in changing their location materially but by surfacing so as to make them passable at all seasons. Remains of some of our early stage coach roads are still visible in this state, one of the best examples I have seen was the remains of the Augusta-Indian Springs road in Jasper County. Today the location of a new road, shortly to be paved, follows very closely this early road. Thus when the internal combustion engine appeared on our highways, they were sufficiently improved to make the average man realize that no longer need he be dependent upon water or rail for transportation. He could at last be his own engineer and make his own time table going wherever he desired.

We thus see that water transportation is so limited in area in this country and speed has become such an important factor in the present day life of our people that independent, individual transportation over highways, with constantly increasing improved road mileage, is such that other means of transportation can neither curtail nor destroy. Co-ordination is necessary and advisable but the "greatest good to the greater" number idea prevails and business will adjust itself to this situation.

While most of our highways were "byways," and the use of these "byways" destroyed the effective use of the automobile in one season, people nevertheless were using automobiles by the thousands. State Highway Departments sprang up over night and the Federal Government, after several years of study by a Congressional Committee, decided the Congress was responsibile for a portion of the necessary expenditures for highways and among other reasons given, declared that the National Defense demanded it. This meant roads and bridges must be so located and constructed that they will maintain vehicles needed to transport material of whatsoever kind in time of emergencies.

Thus the State Highway Departments, in order to participate in Federal funds, were faced with the problem of improving and coordinating the then existing system of highways on a nation wide rather than state basis. This meant traffic surveys to determine location and quality of construction needed in each locality, research of road materials to determine the most durable kind, establishment of road systems in and between the states using the most direct source of communication, proper design of road bed and drainage, erection of uniform safety devices and directional signs in all the states and a coordinated plan made into law to control the size, weight and speed of vehicles on the highway.

In order to coordinate principles, laws and practices between all State Highway Departments and the Bureau of Public Roads of the United States Department of Agriculture (which has supervision of and disbursement of funds for all Federal Aid Roads) thus has come into being a coordinating organization known as the American Association of State Highway Officials, and in addition the Highway Research Board of the National Research Council. All of these organizations through tests and experiments have evolved our present day methods of road building.

The evolution of the modern highway may be considered as passing through four distinct stages before our modern paved road becomes an actual fact. These four stages or phases of highway building may be considered as: The location of the highway which involves a study of traffic needs, most economical and permanent site for the roadbed and actual survey thereof; the financing of the road which involves the cost of grading, and paving (including a study of paving types best suited for the particular road); the construction of the road; and finally, the maintenance of the completed roadway.

It shall be the purpose of this paper to discuss only the first phase of road building;namely,the Location of the Highway and the problems involved.

The reasons for this are twofold - First,the lack of any text or writings which touch on this most important phase of roadbuilding in a practical manner that will enable one to realize the mumerous problems involved,and the most desirable and practical solution to the problems themselves; Secondly, my observation that few engineers engaged in highway activities really grasp the principles involved and need for adequate location of our highways;there being an almost universal opinion among highway engineers that they can locate a highway anywhere at any time,never realizing the special training required to properly locate a highway. The truth of these remarks is all too apparent to the careful observer as he rides over the beautiful paved highways of this and other states and sees the colossal blunders caused by some engineer who may be a specialist in grading,paving,or bridge construction,trying his hand at location without the slightest conception of the factors involved.

It shall be my purpose to show first the need of proper location,how to go about securing a grasp of the factors involved through a study of the economics of highway location, how the work is directed,supervised and organized from office to the field,how the field data is secured and utilized,and finally,what conclusions may be reached. It is hoped that this paper may accomplish my objective which is to show the need for experienced Locating Engineers and to give the student of Highway Engineering a brief outline that will enable him to tackle the actual operations in the field with the assurance that he is not going at his task blindly.

E C O N O M I C S

STATE	AREA Square Miles			POPULATION		HIGHWAY EXPENDITURES		[illegible]				MOTOR VEHICLE REGISTRATION	
								State System		Rural System			
	Water	Land	Total	1900	1930	1904	1931	Total	Surfaced	Total	Surfaced	1912	1931
Alabama	719	51279	51998	1828[illegible]	2646248	$ 378[illegible]	$ [illegible]	5526	[illegible]68	62331	16196	[illegible]	246000
Arkansas	810	52525	53335	1311564	1854482	682000	28000000	8810	6866	60739	2018	2000	181000
Florida	3805	54861	58666	558542	1486211	437000	24000000	6663	5794	[illegible]	11601	2000	323000
Georgia	540	58725	59265	2216331	2908506	[illegible]	23000000	7124	3916	[illegible]	11006	19000	321000
Louisiana	3097	45409	48506	1381625	2101593	545000	41[illegible]	10509	7549	25044	4654	7000	263000
Mississippi	503	46362	46865	1551270	2009821	340000	16[illegible]	6101	5337	5583[illegible]	12613	5000	184000
North Carolina	3686	48740	52426	1893810	3170276	624000	28[illegible]	8705	7730	45091	14226	5000	429000
South Carolina	494	30495	30989	1340316	1738765	334000	35000000	5993	4866	51733	13936	[illegible]	204000
Tennessee	335	41687	42022	2020616	2616556	729000	45000000	7044	5960	60909	12058	[illegible]	351000
Virginia	2365	40262	42627	1854184	2421851	688000	27000000	7688	5602	52269	6979	[illegible]	379000
TOTAL	16354	470495	486699	15956955	22954309	5452000	287000000	74163	55208	532185	105287	[illegible]	2881000
United States	53015	2973774	3026789	75994575	122775046	59527000	1618090000	324496	226221	[illegible]	467338	1010000	25814000

HIGHWAY STATISTICS FOR THE SOUTHERN STATES

TABLE I

ECONOMIC PRINCIPLES

When one considers the vast amount of money now being expended on highways, and the number of men given employment, he realizes that highways must have some economic value to justify their existence. From a study of Table 1 he sees that the growth of motor vehicles and highway expenditures are enormous, and that the number of miles of road on the State and Rural Systems yet to be improved is even greater than has been accomplished to date.

The per capita cost of highways in Georgia, alone, was $7.88 in 1931 and $5.98 in 1932; and the question arises as to how it can be determined if higway funds have been wisely and economically expended, and what proposed, or future, roads are feasible and desirable. Also what roads of our present system justify improvement and further expenditure of funds.

From the above it may be readily seen that economics play an important part in highway location, for it determines what roads shall be improved or built, and to what extent. Before a highway can be located the Engineer must know what type of traffic to expect, how heavy, and the territory it serves, to intelligently locate the road.

Upon the three factors: type of traffic (as passenger cars, busses or trucks); number of each; and territory (as local farming section, commuters to large population centers, inter-state, or intrastate) served; are determined the limiting points of the location. For upon these factors the grades, curvature, and to a large extent the actual location, in relation to localities, is decided upon.

It shall be my purpose to discuss highway economics only briefly. I shall discuss only that phase affecting actual location,ignoring such phases as cost,except as it affects the location,and its closely allied topics of maintenance,operation of motor vehicles,and highway financing. Such topics as the determination of improvements on present roads by rebuilding and relocating;and how to determine future routes,and make the present and future routes safe for the traffic they will have to carry,will be discussed.

The initial step in a study of the economics of highway location is the securing,and study,of a traffic census on the road under consideration-whether it be to determine if a present route needs improving,or if a new route between two terminal points is desirable.

This traffic census will show the type and density of travel at the points studied and upon these facts an estimate of present and future traffic needs can be made;and the road can be so located or relocated as to take care,not only of present but,of future anticipated needs. If taken over a complete system,as all roads on a State Highway System,it will show the geographical distribution of traffic;type of traffic; measurement of the relative use of primary,secondary,and third class highway systems;and the establishment of the fact and rate of traffic growth.

All States,in varying degree,are faced with the same situation - an isufficiency of revenue to meet the needs of increasing traffic as rapidly as they should be met. All,therefore,have in common two problems to solve:(1) The setting up of a plan of improvement,adjusted to the States financial resources,which ultimately will meet traffic requirements;and (2) the establishment of an order of priority among the numerous improvements that must be made.

Priority of improvement can be decided very satisfactorily upon the basis of present observed traffic;but the development of a plan of improvement which will recognize and provide for future traffic needs must have as its basis an estimate of future traffic density as well as a knowledge of the present flow. This is essential to determine what locations are,and will be,needed;and their priority - for the whole foundation of future traffic needs is based on proper planning and location at the present time.

In addition to the use of the census data for purposes of broad planning,there are a number of specific problems, in dealing with which an exact knowledge of traffic density and characteristics is of primary value. Some of these other uses of the data are suggested merely by stating a few of the more common highway problems,viz:(1) The establishment of a maintenance program and expenditures thereunder;(2) whether to pave or treat a road on which the existing surface is of low type;(3) the decision as to whether a gravel surface has reached the limit of economic use;(4) the determination of the economy of snow removal;(5) the necessity for special design,or relocation, of highways near large cities to accomodate truck traffic of high density and great weight;(6) the determination of the amount of foreign and tourist traffic,a factor in determining road service,and location,and fixing of gasoline tax rates;(7) the determination of pavement widths;and (8) problems of traffic regulation and highway safety.

This list is not exhaustive,but it is clear that with the exception of (2) and (3) all the other problems are closely related to highway location,and that the solution of each of the problems mentioned is dependent upon a precise knowledge of the traffic to be served;and the theory and mechanics of highway location. Incidentally it should also be apparent that a variety of facts concerning the traffic are required for the solution of the various problems.

In planning a traffic survey it is essential,therefore, that there shall be a clear understanding of the methods to be employed in converting the basic data to the solution of the problem - otherwise essential data may not be obtained,and much gathered that is later found to be useless. The methods employed must be carefully designed to supply a maximum of information,of precisely the kind required,at a minimum of expense.

The discussions and recommendations that follow deal only with the data required to assist in determining the need for a location or relocation,and to aid the locating engineer in visualizing the problems confronting him. For any one interested in other phases of traffic counts they will find much data pertaining thereto. I have listed several publications, particularly those of the U.S.Bureau of Public Roads,which go quite fully into this subject.

Going further into the matter of a traffic census we find that the selection of station locations is affected considerably by the character of the data to be secured and the objectives of the survey. If the primary objective is that of measuring annual use of various road systems-i.e.,Federal-aid routes,U.S.Highway routes,State routes,County routes,etc.-

stations must be so located as to provide a representative sample of traffic upon each. If the comparison is between sections of the State,each section must be assigned a number of stations sufficiently large to give a fair sample.

If relocations or reconstruction are to be based upon traffic data,stations should be carefully located and with as much preliminary knowledge of traffic conditions as possible. For example,if two alternate routes of different length between two cities exists,one in good condition and one in poor condition,stations should be placed upon each route and the origin and destination of vehicles ascertained. This will usually disclose that improvements or relocation of one of the routes will result in its exclusive use except for purely local travel. The variability in traffic is considerably different in urban and rural areas,and stations should be so located as to measure these differences accurately. Usually this may be done by designating as "urban" those areas within ten miles of the larger cities,and considering all other territory as "rural",

Key stations are those at which traffic information is most important. They are generally located at the intersections of all main routes,and the information obtained at them should be most complete from the standpoint of the amount and detail of the data secured,and from the standpoint,also,of the duration of the observations.

Blanket-count stations are those at which only the most important data are taken(viz,number of vehicles)and which may be operated by inexperienced personnel. These stations are usually operated a smaller number of times and are located upon the relatively unimportant routes,or at intermediate points between key stations on the main routes where a closer measure of variability in traffic density is desired.

Altho the most common method of making traffic counts has been to station a person at some point or location to count traffic and record results on a form or tally sheet,it is possible,today,to do this with mechanical counters which have been very highly developed. Some of these devices operate by hand while others are entirely automatic.

Among these instruments are the electric traffic-flow meter which is particularly valuable where flucuations in traffic densities are important. A traffic tabulator has been designed which records the number of cars passing a given point during periodic intervals,and still another electrical recording device is one that can be used to count both persons and vehicles passing a given point.

It is thus seen that a traffic census is a valuable adjunct to the Engineer in charge of Plans and Surveys as it gives him a foundation on which to plan his future locations, determine what relocations are needed,and gives the Locating Engineer a definite idea of the type,density,and direction of traffic the road he is locating must handle. As an example of this we find that prior to the building of the New Jersey High-Level Viaduct,at a cost of $5,200,000 per mile,that an intensive study of traffic flow was made(Public Roads.Vol.14,No.12)before the final location was determined and field parties sent out.

It may therefore be taken as axiomatic that no matter under whose guidance the organization of motor vehicle operation is developed,there remains the present problem of intelligently planning highway systems to serve this(motor vehicles)rapidly growing method of transportation. We can also consider that the same basic economic and engineering principles of management that exert such a controlling influence in the field of private business should govern the public business of production in the highway field as well.

Applied to the public business of a State responsible for developing a connected system of improved highways to facilitate the transportation of people and commodities,the first basic principle of production management is that the various sections of a highway system selected for improvement and the type of improvement chosen for each section should be based upon the present and expected future traffic demands,modified by the various physical and economic characteristics which affect the choice of specific construction types to be built on the various sections of a State Highway System.

The plan of State highway improvement may materially alter the economic and social development of a people as a whole or any section thereof. The location and improvement or lack of improvement of a given route is of great importance not only to the traffic of the immediate locality but also to the traffic of larger areas. Therefore the development of a system of highways should not be judged as miles and types of highways constructed each year,but considered in terms of the movement of people and goods. The planning and construction of a connected system of highways deal in fact with the destiny of localities and States,their agriculture,their industries,the growth of suburban areas adjacent to centers of population,and the social activities of a people. This is a tremendous social responsibility and not merely a problem of physics concerning mixtures of material and labor into what we term the modern road.

Altho costs are not an important item in the factors involved in the mechanics of location they <u>must</u> be considered from the standpoint of economics as to which of several routes will ultimately be chosen after a study of all factors involved, and thus have a decided bearing on the probable choice of terrain for the final location of a road. The cost of the actual location is a minor item in the construction of a road,but the cost of that particular piece of location has a most important bearing in figuring the cost of a route both from the standpoint of the actual financing of construction operations;and the intangible item of costs to traffic figured on a basis of time and distance saved and depreciation of the vehicle. Authorities differ in the determination of this latter cost and it is not my purpose to go into that item very deeply - suffice to say it deserves serious consideration by the locating engineer in deciding on choice of lines for his final location.

A first principle of highway economics is that the cost of highway transportation,including both roadway and vehicle costs,should be the lowest possible consistent with adequate service.

Cost of highway transportation is not necesssarily financial costs,but an intrinsic cost that every locating engineer,and highway planner,must consider as he does that of money. This may be best illustrated by Mr.W.W.Crosby,Const. Engr.of Coronado,Calif.,who quotes(Proceedings A.S.C.E.Nov. 1933)Prof.Charles B.Breed in discussing the cost of highway transportation as pleading for a clear distinction between the cost and the value of transportation. Both factors must be properly appraised to determine whether the expense is justified. According to Prof.Breed a highway may be entirely commercial or it may serve partly for school transportation and for protection as well. This latter part being particularly applicable to those States having a State Constabulary and Rural Fire Departments. Quoting Prof.Breed:"It may be impossible to express these values in money,yet these may be so obvious as to carry unanimous public approval of a policy involving a road cost well above any saving that can be computed in dollars and cents". Thus, according to this authority,the justification of most large highway improvements will not be found entirely in their effect on transportation cost,but in their influence on transportation values,of which cost is only one element.

In the March 1934 issue of the Proceedings,of the American Society of Civil Engineers,Mr.C.C.Wiley,Asco.Prof. of Highway Engr.U.of Ill.,says that "Highway expenditures are in no sense capital investments. They are the direct cash outlay by the people for the purchase of a service perhaps as fundamental to present civilization as government itself". He adds further that "It must be remembered,however,that the cost of a road improvement(including interest on bonds,if any),is actually paid out by the people in the form of taxes,while the savings accrue later by the reduced costs in the purchase of other items incidental to the use of the road".

From the above discussion we see that the element of service must be considered jointly with that of cost. We can divide the general field of motor-vehicle transportation into three major classes of service. First is the local distribution of commodities and local transportation of people. This service constitutes in tonnage the bulk of the motor truck movement and is primarily the distribution of goods within cities and their suburban areas. In passenger transportation the principal function is also mass transportation within local areas.

The second principal class of motor-vehicle service supplements existing rail and water service by extension of freight and passenger service into areas not served by rail or water lines;substitutes motor-vehicle service for rail operation of unprofitable branch lines;and provides a combined service in conjunction with railroads or boat lines or both. The primary function of the motor vehicle in this joint movement is the movement of people or goods in the short haul.

The third class of motor-vehicle service is the so called long-haul transportation. This type of service is not important as to quantity of movement nor would it appear economically sound. However it appears to be increasing in popular favor at the present time primarily in the movement of people rather than in the movement of commodities. In the later movement long-haul transportation is generally limited to movements in which speed of delivery or some special characteristic is the principal determining factor.

Based upon the classification of motor-vehicle service in planning for a new,or the improvement of an old,route or system the major problem is not one of the particular type of materials to use,for class of service for which intended, traffic expected and money available determine this;but rather whether to build or not,and how much highway service should be furnished a given area. Upon the solution of this problem, properly,depends the well-being and progress of a people. Considering the improvement of highways from this point of view there can be no question concerning the necessity of developing sound plans for highway improvement over a period of years in each State,and of providing the necessary money to carry out economically the proposed plan of improvement. Based on personal observation I favor,once the plan has been improved,the immediate start of preliminary surveys for the purpose of deciding upon future permanent locations,cost studies,and the securing of Right of Way,or options on Right of Way,in order to avoid bad alignment in the future due to prohibitive cost of,or failure to secure,the necessary Right of Way. This is particularly applicable to routes leading into or by-passing large centers of population,and whenever funds and personnel can be secured it should be undertaken rather than wait until construction is ready to start on the proposed improvement. The advisability of this can readily be seen by observing the present narrow and winding routes thru our cities.

The principal classes of highway improvement are: (1) New Construction;(2) stage construction;(3) reconstruction; (4)building,or widening,of bridges and culverts;(5)highway and railroad grade separations;(6)widening of present highways;and (7) methods of guiding and safeguarding traffic. It is apparent that before any of the seven classes of improvements can be undertaken the Locating Engineer must first decide upon the location and furnish all necessary surveys and information incidental thereto,before these improvements can get under way. A clear understanding of the economics involved plus a thorough grounding in the basic principles underlying Highway Location are essential,here also, before the success of the improvements can be assured.

It is well at this time to bear in mind the following classifications of roads as given by the American Association of State Highway Officials,viz (1) Primary Roads,comprising the Federal and State Systems;(2) Secondary Roads,the principal county trunk highways,or State-Aid Highways;and(3) Third-class roads,the purely local township roads. To these should be added city and town streets. It is also well to bear in mind that the parties that would be benefited by the completion of a State Highway System are: (1) The United States,(2) The State,(3) The local communities,(4) Real Estate,and (5) The road users.

The above furnishes the locating engineer with the facts upon which to base a decision when he is confronted with the question of sacrificing a location for ability to secure right of way.

In any discussion of the economics of location the factor of cost is paramount and,as noted before,may be summarized as the cost of transportation when the question of a plan or new improvement is contemplated,and as a definite financial outlay which must be kept at the minimum consistent with sound engineering,safety and cost of transportation,when the actual location,on the ground,is being made.

The cost of transportation consists of two elements: the road cost and the vehicle cost. While certain types of improvement may actually increase the annual road cost,they decrease the annual vehicle operating costs sufficiently to more than offset the increased road costs. The net result is transportation for the traffic known to use the highway,at a cost less than that incurred before the expenditure for the highway improvement.

To place the above on a mathematical basis Dean Thomas R.Agg in the September 1933 Proceedings A.S.C.E. gives the following expressions:

(1) Highway transportation costs=(Highway Costs)+(Vehicle Costs)

$$(2)\quad \begin{array}{l}\text{Comparative}\\ \text{cost of high-}\\ \text{way transport-}\\ \text{ation per vehicle-}\\ \text{mile on a specified}\\ \text{highway}\end{array} = \left(\begin{array}{l}\text{Highway}\\ \text{costs per}\\ \text{vehicle-}\\ \text{mile to}\\ \text{traffic}\end{array}\right) + \left(\begin{array}{l}\text{Cost of}\\ \text{vehicle}\\ \text{operation}\\ \text{per mile}\\ \text{of travel}\end{array}\right) - \left(\begin{array}{l}\text{Contribut-}\\ \text{ion by}\\ \text{vehicle to}\\ \text{road funds}\end{array}\right)$$

$$(3)\quad \begin{array}{l}\text{Annual}\\ \text{Highway}\\ \text{Costs}\end{array} = \left(\begin{array}{l}\text{Interest}\\ \text{on the}\\ \text{invest-}\\ \text{ment}\end{array}\right) + \left(\begin{array}{l}\text{Annual}\\ \text{cost of}\\ \text{routine}\\ \text{mainten-}\\ \text{ance}\end{array}\right) + \left(\begin{array}{l}\text{Annual}\\ \text{adminis-}\\ \text{tration}\\ \text{costs}\end{array}\right) + \left(\begin{array}{l}\text{Annuity}\\ \text{for de-}\\ \text{preciat-}\\ \text{ion}\end{array}\right) +$$

$$\left(\begin{array}{l}\text{Annuity for}\\ \text{periodic}\\ \text{repairs at}\\ \text{intervals of}\\ n' \text{ years}\end{array}\right) + \left(\begin{array}{l}\text{Annuity for}\\ \text{periodic}\\ \text{repairs at}\\ \text{intervals of}\\ n'' \text{ years}\end{array}\right) + \ldots\ldots\ldots\ldots$$

As a result of such studies the Ohio Department of Highways (Engr.News-Record,Vol.112,No.10,March 8,1934)relocated 1.457 miles of road,and built a viaduct 1,118 feet long,at an expenditure of approximately $306,000 on the Cumbérland Road near St.Clairsville,Ohio. This relocation has ten curves with a total curvature of 226 deg.and a minimum radius of curve of 520.78 ft.or 11 deg. The old road had 21 curves with a total curvature of 1196 deg.and radii varying from 53.71 to 143.24 feet. Little was saved in maximum grade(7.88 per cent old, 7.36 per cent new)but length was reduced 670 feet.

Very elaborate studies were carried out prior to the location of the New Jersey High-Level Viaduct,previously mentioned,to determine the economiceffects of its location. In discussing this viaduct Mr.Fred Lavis,Construction Engineer of New York City,says that "there are two elements,or two major types,of design in a project of this nature: (1) The design of the route;and (2) the design of the structure which carries the route". It is the former that we are primarily interested in.

In their studies of the economics of the problem the New Jersey engineers show the capitalized value of delays due to openings of draw bridges,on the old route,as $12,215,600 valuing the vehicles at 2 cents per car minute. The traffic being 18,360,000 cars per annum. Based on this volumne of trafficstudies were also made on the savings resulting from the saving in distance and reduction in grades.

The studies(Transactions A.S.C.E. Vol.95,1931)show thatfrom a comparison of operating costs obtained from various sources,and for the items affected,namely,depreciation;fuel; lubricants;tires;repairs;and miscellaneous a fair average cost of operation for the traffic expected to use this highway to be 2.18 cents per 1000 feet. Assuming the 18,360,000 vehicles will use the new highway annually,the decreased operating costs,due to shortened distance of 1000 feet,will be $400,248 per annum,which,capitalized at 6%,indicates that the sum of $6,670,000 could profitably be spent to save that distance.

From experiments made at Iowa State College indicating that the work done by a motor vehicle to raise a weight to a height of one foot is approximately equal to the force required to propel the same weight over a level distance of 50 feet on good pavement;the New Jersey engineers found that they could determine the savings resulting from a reduction in grade.

Taking the data previously used, it will be found that, for the average car on good pavement, the cost of producing power only, that is, fuel and oil, is approximately 3.22 cents per mile, or about 0.03 cents for 50 feet. Therefore this was assumed to be the cost of raising the average car one foot. Based on the traffic of 18,360,000 cars per annum, the cost of one foot of rise and fall at the rate of 0.03 cents per car is approximately $5,508, which, capitalized at 6%, represents a value of $91,800 as the amount which could profitably be expended to limit one foot of rise and fall.

No experiments were made on the money savings of a reduction in curvature. However, for highways with sharp curvature, where visibility is reduced, or conditions exist which slow up traffic, there will be costs due to delays and, in case of maximum traffic demand, costs due to decreased capacity of the highway to carry traffic.

It has been said that the New Jersey High-Level Viaduct and the studies made for this project are the foundations on which future "express" highways will be designed. Regardless of this fact it shows what must be done to solve the problems of locating roads leading into, and contiguous to, large centers of population.

In dealing with the subject of economics one other factor of vital importance is rarely stressed or thought of by the average Locating Engineer - that is the factor of safety on our highways. The average person who gives this matter any thought usually considers it a problem for the police or traffic

FIG. II

View of Blind Curve on the

Washington - Annapolis Road

Maryland

patrol to solve and as far as the highway engineer is concerned his responsibility ends with the placing of warning signs and seeing to their proper maintenance.

Too little emphasis is given to the part that safety should have in the location of highways. Mr.B.P.Harrison,Associate Highway Engineer of the U.S.Bureau of Public Roads,Washington,D.C.,in discussing highway location in the Proceedings of the American Society of Civil Engineers asks "Should not the engineer feel some responsibility for the lives lost due to a faulty location?"

Something must be done to reduce the toll of human lives taken daily by automobile accidents. It is obviously true that our roads are crowded with poor drivers,that the tendency of the day is for increased speed - which is answered by the States increasing the legal speed limits,and by the manufacturers building,and advertising,their cars for speed.

Is the engineer,however,doing his part by insisting upon proper locations? A study of Figs.II,III,and IV forces one to the conclusion that little if any thought is given to safety in locating a road. Economy and Right of Way difficulties have played to great a part in past locations,and probably explains the winding road shown in Fig.IV which could easily have been a long tangent,as a study of the ground and the photograph will show.

The engineer responsible for highway locations should spend a little more money,based on sound economic and engineering principles,to make the highway "fool-proof"by ignoring local and political pressure and giving his attention to the elimination of grade crossings,proper location of bridges,

FIG. III

An Underpass Between

Crawford and Union Point

Georgia.

and adequate sight distance for both vertical and horizontal curves. The Locating Engineer has a wonderful opportunity if he will but take advantage of it.

The Locating Party should not be handicapped by having to consider right-of-way with respect to the location. The road should be properly located without considering right-of-way, except in those isolated cases where a slight shift in the alignment will not materially effect the location, but will prove of material benefit to the property owner. Where trouble may be experienced in securing right-of-way a well established, and well trained, legal department should be available to handle the matter and relieve the engineering department of that responsibility.

L O C A T I O N

GENERAL CONSIDERATIONS

In undertaking the actual location of a road, or in any discussion involving a location, the ONE thing to be borne in mind at all times is that: THE ONLY PERMANENT FEATURE OF A ROAD IS ITS LOCATION. In this one sentence may be summed up the principles of highway location, and upon this axiom only can the success of a location be measured.

Mr. Charles S. Hill, Associate Editor of Engineering News-Record, writing on modern roads in a recent issue (Vol. 111, No. 24, Dec. 14, 1933) of his publication makes the following statement: "Except right-of-way, line and grade are the only road elements for which permanency can be insured in the original design. All other elements - roadbed, surfacing, ditches and slopes, - can be given only limited life. In the modern road, therefore, design is directed to line and grade that will be final. This may be stated as the <u>first principle of practice</u>. Compliance with it is dilegently striven for in the best recent line and grade design."

That Engineers realize this fact can be best illustrated by quoting Mr. Fred Lavis, President of the International Railways of Central America, who, writing in the August 1930 Proceedings American Society Civil Engineers, says that: "There has developed, however, in recent years a demand for a new type of road - a road more nearly analogous to the railroad; laid out on an entirely new right-of-way and designed and built primarily to meet a demand for transportation. Such roads must necessarily be designed from the point of view of their users rather than that of owners of abutting property."

Mr. Lavis than goes on to say that "The design and

FIG. IV

Winding Road Between Kings Mountain and Gastonia, N.C. on U.S. 29.

construction of this more modern road are based primarily on the needs of a large volume of intensely mobile traffic which desires to move from one place to another with the least resistance compatible with the physical conditions of the territory thru which it must pass. It is a development of modern transportation which must be recognized and provided for".

In an article on Highway Financing (Proceedings A.S.C.E. Feb.1932) Mr.J.C.Carpenter says: "The necessity for careful and extensive planning of location for highways is much more obvious than ever before. In issuing bonds for highways it has been considered sound to assume that the location,grading,and drainage structures are permanent features,but numerous instances are found in which modern traffic demands locations which mean the abandonment of considerable sections of these old roads. The planning cannot stop at county lines,but must be extended to develop locations which will not be subject to change".

That Georgia,in the past,has given too little thought to permanency in location is self evident as one rides thru the state. It is brought sharply to mind by the following comment carried in the exchange column on the editorial page of a recent issue of the Atlanta Journal. This comment copied from the Oglethorpe Echo of Lexington,Georgia says: "After having taken a ride from Lawrenceville to Atlanta last week we are of the opinion that more good might be done autoists by straightening out curves than in building new highways. A safe estimate is that around a million dollars a year could be saved in gasoline and tires,to say nothing of time,by eliminating curves on that stretch of highway". This road like many others was paved on the old roadbed without a paving survey being made or any additional grading being undertaken, in the county's eagerness to have a paved road. This took place in the early days of the State Highway Department before it could demand and insist upon satisfactory surveys being made and adequate right of way secured. Yet the lesson has not been learned by many of our so-called Locating Engineers for they still follow the line of least resistance by locating along present alignment, rather than strike out on a new and preferable location.

In considering the actual location: Direct line and low grades are essential. Their realization may be only a task of rectification as the modern main road is fixed as to direction and general alignment where a road already exists. According to, the article by, Mr. Hill there are few instances where complete departure from an established travel thoroughfare is allowable or economically justified. He gives as his main reasons for this statement that: "(1) A real investment exists in the old road right of way, cuts and fills, roadbed materials and drainage structures, on which little can be realized if the road is abandoned; (2) the owners along the road have a vested right not to have the main road taken away from them; and (3) only exceptional traffic demands warrant investment in a completely new road.

I can agree with the statement of Mr. Hill if a study based on the principles heretofore brought out are adhered to, and a preliminary survey or reconnaisance shows the advisability of following the present alignment and easing grades and curvature. If this be stated as a general principle I must take issue with Mr. Hill for (1) the right of way, cuts and fills, can be turned over to the county as part of its local rural system and thus the investment will be retained, and in those cases where complete abandonment takes place the investment will be comparatively negligible when compared with the transportation costs of the old and new locations. The drainage structures in most cases will have to be rebuilt on the new alignment,or where of a high type originally,they will have to be widened. It is not frequent that a loss will result from such abandonment,but in cases where large strcutures are involved this must be given serious consideration and study. (2) as mentioned previously the rights of abutting property owners must be considered secondary to the public welfare,as attested by several recent decisions of the Georgia Supreme Court - notably that involving the "Peach Orchard Route"between Augusta and Waynesboro - wherein the right of the State Highway Board to abandon an existing route and construct an entirely new road was upheld;and (3) where traffic warrants a relocation of an existing route it will warrant a new road if a reconnaisance shows a more direct and an easily constructed route. In all cases practice sets no standards - each road is considered a separate problem,and the solution is individual to that road.

System requirements enter into consideration,but they have more relationship to the classification of roads for improvement than to the solution of the problem of the individual road line and grade. This problem involves (a) engineering economics and (b) safety of travel. Both are vital factors in rectification practice as well as in new locations.

I have in mind three locations on the Georgia Highway system which will illustrate my contentions in reference to Mr.Hills statement. All three of these are entirely new locations rather than relocations,had Mr.Hills principles been observed, which in this case would have followed the lines of least resistance inasmuch as powerfull pressure was brought to bear to retain the then existing routes.

The first of these locations was the Greensboro-Sparta Road, State Route 15, where the old road via Harris Mill and Veazy was abandoned for a more direct route thru White Plains and Mount Zion. The new route saved distance, had easier grades and superior alignment, fewer large drainage structures and entered Sparta on an existing bridge over the Georgia Railroad, thereby eliminating the necessity of an expensive and poor grade crossingproject. Both routes served approximately an equal number of people, with the new route serving the larger communities. The existing route would have involved some very heavy rock cuts which were missed by the new location.

The second location was that from Waynesboro to Augusta, State Route 21, better known as the "Peach Orchard Route" during the lengthy court battle in which it was involved. This location almost split the difference between the existing route, which could have been easily, and was later, improved for paving, and a local road slightly shorter than the first but more expensive to improve. These two routes were discarded for an entirely new route, which had to be constructed, because it saved several miles of distance, a great consideration when paving is involved, had straighter alignment, easier grades and curves and fewer drainage structures than either of the other routes. Altho the existing route had fine concrete bridges, that could be easily widened, in most instances the other factors outweighed this very important item of cost. The new road served fewer people than the other two, but more than either of the others taken sep-

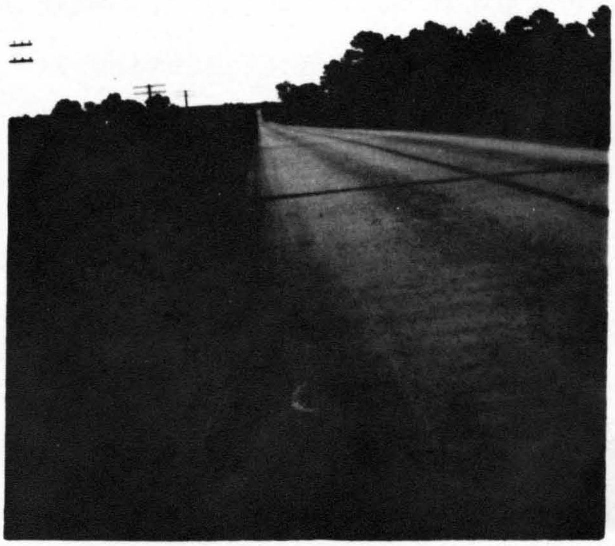


FIG.V

An example of good alignment

on Atlanta - Athens Road

Georgia Route 8 (U.S.29)

arately since connecting roads made it easily accessible to people living anywhere along the other two routes. No tangent over a mile or two in length could be secured on either of the other roads, whereas on the new road approximately a 14 mile tangent was obtained. The grades were more moderate, and it crossed Brier Creek Swamp, illustrated by Fig. 1, at the narrowest point. It also eliminated a grade crossing on the existing route, and utilized several miles of an excellent existing county road.

The third location, illustrated by Fig. V, is on the Athens - Atlanta Road, State Route 8 (U.S. 29), between Bogart and Lawrenceville. Between Bogart and Winder much of the then existing road was utilized, but between Winder and Lawrenceville an entirely new location was made. The new location was on the South side of the Seaboard Air Line Railway, and discarded all of the then existing road on the North side of the railroad. As in the two cases previously mentioned the old road was not abandoned but was turned back to the respective counties as a local road to serve purely local traffic. This location saved, as I recall, about 4 miles of distance, tho serving fewer people along the territory traversed at the time of its construction, and had much easier grades and vastly improved curvature than did the old road. It also eliminated about 4 railroad crossings.

The decision to abandon these old routes were made by the Locating Engineer only after a thorough reconnaisance and study of the area between the control points of his survey, and after a proper consideration of the economics involved, a knowledge of future traffic possibilities, and the permanency of the locations in question. This Engineer realized that State Highways should be located for present and anticipated traffic requirements so that - whether he be tourist,business man,or farmer - the user of the highway can proceed along his route and accomplish his purpose or his duty or receive his pleasure or culture with ease,directness,safety,and economy. Any plan or system which does not take these features into account is running contrary to sount public policy. As a testimonial to the ability of this Engineer stand the Supreme Court decisions in each case and the completed road itself serves as his best testimonial.

Due to right-of-way difficulties it has not always been possible to comply with the above statement of policy,but with the adoption of plans whereby the revenue for State highways comes from State sources,the solution of this problem becomes easier and the "dog will begin to wag the tail"instead of the contrary,which has been the case in many highway locations.

Each State Highway Department has an organization for location. According to the U.S.Bureau of Public Roads there is no set organization,at the present time,that can be mentioned as representing all States since the set up in each varies. The usual organization,however,is one wherein an Engineer,which I will call the Engineer of Plans and Surveys,has direct charge of all Locating Parties-he being responsible to the Chief or State Highway Engineer. In Georgia there are several parties in each of the three Divisions reporting to and responsible to the the Division Engineer. They are coordinated only thru an Assistant Highway Engineer in charge of Surveys and Construction who supervises their work. This is not the ideal system as it lacks the coordination and supervision of a centralized system wherby all locating parties worked out of,and were directly

FIG. VI

View of Widening Operations On U.S. Route 1

Between Wahington and Richmond, Va.

Showing present blind curve with newly graded

roadway on continuation of old tangent.

responsible to one man in,the General Office. This centralized system affords the means of determining a plan then coordinating all surveys to fit in with that plan. Very frequently in Georgia a survey is stopped at the county or division line without thought to,or effort to secure,a proper tie in on the other side of the line. This is particularly bad where the boundary happens to be a large stream.

Some states have very elaborate Right-of-Way and Legal Departments working in coordination with the Engineer in Charge of Surveys. In all cases it can be stated that the ideal set up is a responsible head in the Central Office who has direct charge and supervision of all field parties. The Locating Engineers are directly under him and before they are ordered to survey a route,he has first completed a study to see how the proposed location fits into the master plan,and is aware of any disputes regarding which localities the survey should go by;so that when instructions are given the Locating Engineer he is also given free rein to make the best possible location between the Control Points fixed by the Central Office.

Before issuing instructions to the field parties a study of each project should be made in the light of the recommendations of the Committee on Highway Location of the American Road Builders Association. In the light of the studies and discussions carried out by this committee,they stress the importance of careful study by competent engineers of all highway locations:

First: To promote safety to the traveling public.

Second: To ascertain the most economical route to build and maintain.

Third: To secure permanence for the road in order that future improvements, such as widening, beautification, and real estate development, may be intelligently undertaken and carried on.

Fourth: To coordinate the location of township, county, city, state, and national highways, thus preventing confusion or duplication of work.

Fifth: To satisfy the growing demand of the public that highway funds should be spent only upon locations consistent with future traffic needs.

It is further recommended that in all such studies the surveys which may be under consideration should be reconciled with the following major requirements:

1. Geographical direction.
2. Cost of constructing roadbed.
3. Cost of drainage structures.
4. Relative cost of maintenance.
5. Cost of securing right of way.
6. Service to through traffic.
7. Connections to intermediate towns.
8. Elimination of railroad crossings.
9. The use of existing road.
10. Local sentiment.
11. General appearance.

In order to issue instructions to the Locating Engineers so that he will be able to proceed without delay on a location, and be informed of the requirements to be met he must know any restrictions placed on the location - for on all highway projects there are administrative controls or restrictions which determine at least the general location of the project,or the route of which it is a part. Thus the termini of the project are predetermined and the intermediate location may or may not be fixed. These restrictions will occur under the following classifications:

1. Major control points of the Federal Aid System determined by the Secretary of Agriculture and the State Highway Departments and subject to modification by joint action.

2. State highways and control points designated by State Highway Commissions under legislative authority.

3. Control points for State highways fixed by legislation.

4. County or road district bond issues used for a part of the construction cost may require a definite location to be followed.

Under conditions 1 and 2 there are opportunities for a general engineering study before the controls are specified and also for a revision of controls based on further engineering investigations. Condition 3 may or may not be based on engineering investigations,or it may permit some departure from the established route at the direction of the State Highway Commission. Condition 4 presents the greatest difficulty because frequently,where local funds are contributed,the detailed location is fixed primarily to serve local wishes. This latter system of financing has been responsible for most of the unsatisfactory locations in the South and Southwest since 1914. Where it is necessary to continue this system of financing in fairness to all parties concerned,the location should be determined in advance of the local arrangements for financing.

Even under conditions 1,2,and 3 there is too great a tendency to follow existing lines of improvement with relatively unimportant control points established; under condition4 this tendency often reaches the point of affecting the details of location. Regardless of how these conditions are imposed they may in effect restrict the work of the locating engineer to mere details of design. Administratively,controls are necessary and should be general in character and limited to the following conditions:

(a) A town or city on or near the general line of the route between adjacent control points of the route.

(b) A town or city of sufficient importance to be a terminal point for the traffic passing between the adjacent controls.

(c) A junction point,preferably near a town or city,of several highways for the distribution of traffic.

(d) Topographical features based on engineering investigations.

Within the limitations established as controls the engineer should determine,as far as practicable,upon an economic location,considering at their relative weights both through and local traffic. This selection will be the line which will provide the long-run least cost,including construction,maintenance, and traffic operations. The shortest line will usually be the economic location for the reason that practically all items of cost,except earthwork and structures,vary directly with the length of the line. In a country of broken topography the cost of earthwork and structures may be much less on the longer line, but the other items of construction,and of maintenace and operation,will usually determine the location. Local traffic can generally be served more cheaply by lateral spurs from the main line than by attempting to give direct service.

One of the usual problems facing the engineer is to determine whether or not to swing the main line from its direct course in order to give highway service to an intermediate point, such as a small town or community. Theoretically, the problem can be solved by estimating the cost of construction, maintenace, and operation for each of the two possible layouts; that is, the cost of the main line direct with a lateral spur and cost of main line on the indirect location thru the intermediate point. This will require the Locating Engineer to make a survey of both routes, reporting on same, and leaving final decision to the General Office - tho frequently this decision is left to the Engineers own judgement, provided local politics do not intervene.

A similar problem is that of combining two or three highways for some distance out from a city in order to reduce construction mileage. While economically desirable, this frequently involves the questionable practice of encouraging traffic congestion at junctions and terminals - a fact most frequently overlooked by the Engineer as well as the layman.

In working out the detailed location further economies can be made by taking advantage of topographic conditions, soils, available local material, or railroad facilities for importing materials (As will be noted later, the Survey Party should note all available local material and railroad facilities in the topographic notes). According to Mr. A.R. Losh, in Vol. 96 of the Transactions A.S.C.E., approximately 4000 tons of material are required per mile of 18 ft. concrete pavement. An increased dead haul of one mile will increase the cost of the road about $1000 per mile. In addition, there will also be the cost of moving construction equipment on and off the job as well as the cost of hauling structural materials. The use of long radius curves reduces the total length of line and the amount of surface widening. For a change in direction of 90 degs.,a curve of 1000 ft.radius gives a line 214 feet shorter than a 500-ft.radius. To widen the curve of 500-ft.radius would require about 938 square yards of additional pavement.

Topographical conditions affect the details of location and,in some instances,are major control factors. All soils which are unsuitable for subgrades,are to be avoided if practicable. Overflow sections require high embankments with costly structures,and,for this reason,valley locations are frequently undesirable. Stream crossings must be selected with the view of reasonable permanency of the banks,suitable foundations,and required span lengths,and they must be within the general location. Grades and curves adjacent to bridges should be reduced to the minimum;and it is desirable to have a tangent of at least 150-feet and a light or flat grade at each end of a major structure.

These conditions permit the driver to adjust his machine into the bridge alignment. In the past,grades have probably received more consideration than other features-altho there are numerous instances of a grade breaking at a bridge without a vertical curve between-due no doubt to the fact that in the past vehicles could not easily negotiate a steep grade, and were not built for speed. Considering the motor vehicles now in use some sacrifice of grade can be made to improve the alignment. Short grades as steep as 8% can be climbed readily by modern motor vehicles,but continuous grades of more than 6% are objectionable. Tangent profile grades are not particularly

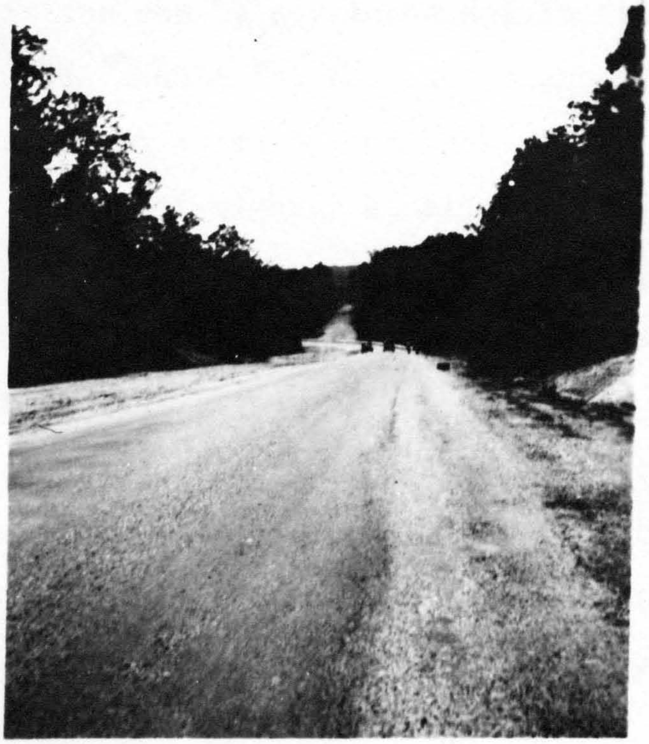


FIG. VII

View of Richmond - Washington Highway (U.S.1) in Virginia. Showing new line graded as continuation of present tangent, to eliminate bad curvature. Note newly widened, and paved, lane on left side of present pavement.

advantageous,due to the headlight glare,and do not justify increased expense. A rolling profile fitting the topography is less objectionable for nite driving. Table 4 shows the recommended minimum requirements for grade and curvature.

Grade separations at railroad intersections are particularly desirable,but not always possible financially. When grade crossings are adopted the line should be located so that future separations can be developed,and in all cases approach curves and grades should not restrict sight distance.

Restricted areas in and near cities are frequent obstructions to direct highway location. This includes parks,golf courses,institutional reservations,cemeteries,railroad yards and airports. Generally,it is impracticable to pass thru these areas and the location must be carried around them. This is also true of cemeteries wherever found. The location should give access to railroads and airports,but should be sufficiently removed to permit of full operation of all facilities without congestion.

Location along a railroad is usually adopted because good alignment is obtainable and right-of-way is easily secured. It has the disadvantage of industrial spur tracks being constructed across the highway,of the necessity for following railroad curvature to a great extent,and of permitting development on only one side of the highway whereas if removed a quarter mile or more from the railroad,property on both sides of the highway would develop.

One of the major problems confronting the engineer is to provide suitable locations,into,through,and around towns and cities. It is necessary to provide suitable connections into the street system of the city. It is also highly desirable to have a direct through connection,even if it may be congested by city traffic,in order to take care of through traffic making a temporary stop in the city. Modern practice is to construct a belt line,or by-pass location,for the through traffic to avoid the city congestion in reaching its destination and to permit the sorting or segregation of traffic for different localities.

The desirable condition for the urban approach,according to Mr.A.R.Losh,would be connections which would permit the distribution of traffic to:

(a) The retail section.

(b) The wholesale and industrial sections.

(c) Railroads and airports.

(d) The several residential sections;and

(e) To other highways by direct connections,outside the city proper.

Many town and city officials believe that the highway should be considered as a continuation of "Main Street" out into the country and that it should be carried thru the principal thoroughfares of the city. This is especially true of cities of less than 10,000 population and the smaller the municipality the more insistent it is,as a rule,that the highway pass thru the main streets. The larger cities have their local traffic problems and as a rule are glad to secure any relief possible by routing traffic over outlying streets or thru the suburbs. In a great many cities,however,highways are taken directly thru retail sections where the streets are congested with street cars,automobiles,and pedestrians. There are numerous street intersections, sharp curves,grade crossings,congestion due to parking and, haphazardly placed traffic lights,as Atlanta for example,in

a

addition to other hazards of city traffic. The through traffic is delayed and local traffic congestion is increased with possibilities of accidents multiplied. Too many towns and cities are placing restrictions on through traffic by means of speed ordinances, stop signs, signals, and other regulations.

These measures in most cases are necessary for the local traffic, but the through traffic can operate better without them and outside of the city. That these facts are becoming more evident to our Southern highway officials and the public can be best illustrated by mentioning the fact that North Carolina has followed the precedent set by several large Northern and Western States, by building by-pass roads around its larger cities. While Georgia is not building any actual by-pass roads it is avoiding the center of the town and building its newer roads on the outskirts of the communities it formerly went thru.

The development of proper approaches to cities, with arterial routes for traffic to and from the city and belt lines for traffic distribution, requires the cooperation of State, County, and Municipal authorities. It also requires a careful traffic study and analysis, upon which to base present and future plans for improvement. An outstanding example of this character of work is the "Plan of Highway Improvement in the Cleveland Regional Area". As a result of this survey the City of Cleveland and its contiguous territory have developed a plan of major road and street improvements for ten years ahead and may proceed with individual projects, knowing their final position in the broader plan.

In a report regarding street and highways in and near Metropolitan Chicago the Western Society of Engineers states that political pressure has determined the location of too great a mileage of highway improvement,and the Society is driving toward the end of getting 100%,instead of 70 to 80%,of the surfaces laid where they will serve best.

FIG.VIII

View of U.S.1 between Washington and Richmond. Showing typical widening of present pavement in Virginia. Note bottleneck caused by narrow bridge in the background. The trusses in left background are the R.F.& P.Railroad Bridge.

GENERAL REQUIREMENTS

The requirements of the U.S.Bureau of Public Roads for the Federal-aid road system are generally followed thruout by the majority of the State Highway Departments. The Bureau classifies roads as Class "A","B",or "C" depending on the number of vehicles per day using the road. Thus:

Class "A" = 1000 up to 5000 vehicles per day.
Class "B" = 500 up to 1000 " " "
Class "C" = less than 500

and above 5000 is classified as a Super-Highway or Boulevard.

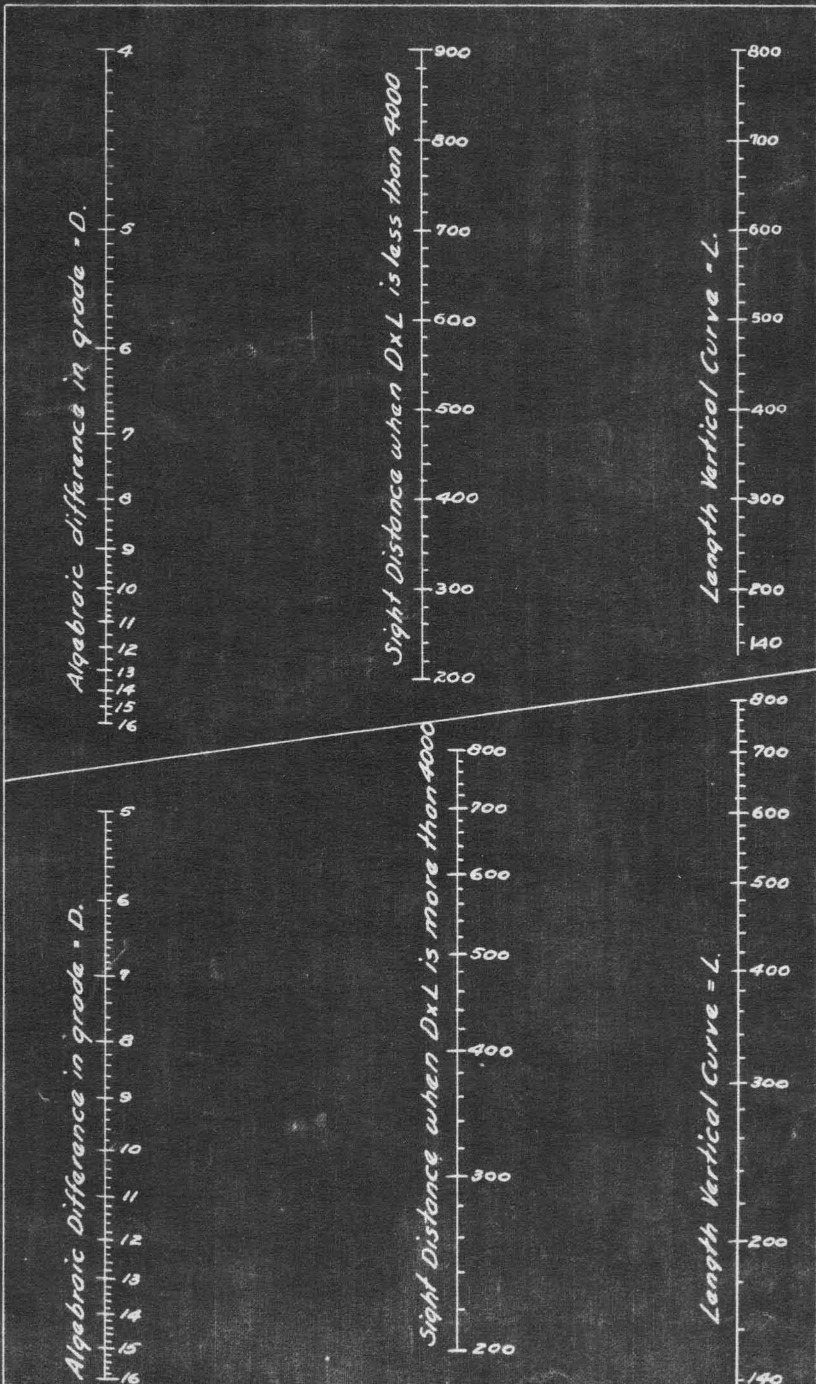
Table 4 gives a summary of the American Road Builders Association suggested minimum requirements for surveys for various classes of roads in different types of country.

Tables 2 and 3 show the charts used by the Georgia Highway Department for determining the required sight distance for Vertical and Horizontal Curves.

In discussing the question of alignment Department Bulletin #1486,of the Bureau of Public Roads,says: "No fixed rules can be laid down,but the following points of merit and disadvantage may prove of assistance in studying any individual location problem". It then lists the desirable features in alignment as follows:

"Maximum lengths of unbroken tangents.
Maximum possible clear sight distance around hill points.
Balanced earthwork quantities (cut and fill).
Minimum amount of overhaul.
Location thru material easily and cheaply handled.
Minimum amount of rise and fall in grade line.
Easy horizontal curvature."

①



Charts for determining Maximun Sight Distances on Highway Vertical Curves
(Eye assumed to be 5 ft. above pavement)

TABLE 2

B

Among the undesirable features in alignment are listed the following:

"Location resulting in through cuts which are apt to drift full of snow in winter.

Location along sidehills of shifting or sliding material or along seepy or wet hillsides.

Location over swampy or seepy material,or over ground where natural drainage is difficult or uncertain.

Location on sidehills having a northern exposure,since they are apt to be wet a greater portion of the time.

Adverse grade.

Sharp Breaks in grade.

Blind curves or restricted sight distance.

Reverse curvature (on account of difficulty of superelevation)

'Broken-backs' or two curves in the same direction with a short connecting tangent."

In speaking of curves and alignment Mr.H.W.Griffin, Field Engineer of the New Jersey Highway Department,says: "Where necessary to have a curve near a summit it should be located if possible so as to extend for some distance on both sides. Where vertical curves are coincident with horizontal curves on summits, pleasing alignment is obtained."

The older practice of placing changes in alignment at the top of hills has been discontinued. It is considered a hazard to traffic. Other conditions being equal,curves should be placed where they can be seen readily by the approaching driver.

In discussing the various minimum requirements the March 1929 (Vol.10,No.1) issue of Public Roads,the publication

SIGHT DISTANCE FOR HORIZONTAL CURVES

CHART FOR DETERMINING MAXIMUM SIGHT DISTANCES on HIGHWAY HORIZONTAL CURVES

Note: These values for sight distances apply when the sight distance is not greater than the long chord of curve, but do not apply when the sight distance is between points on tan. to the Curve. Suggest eye be assumed as 5 feet above pavement.

H.J.B. Dist. No. 7

TABLE 3

of the U.S.Bureau of Public Roads,has the following comments to make regarding the subjects listed:

Sight Distance: "The increase in volume and speed of traffic has made necessary greater sight distances on both horizontal and vertical curves. It is desirable to maintain a sight distance of at least 500-feet,but this may not always be feasible on mountain roads."

Grades: "On main-line highways it is customary to adopt a maximum grade of 5% in gently rolling country and 7% in rough country,but it is no longer considered good practice to resort to sharp curvature in order to avoid grades somewhat steeper than 7%. If local conditions permit either a 7% grade with a sharp curve or a short 9% grade with a wider curve,the latter design is thought to be the better practice because it is safer for modern motor traffic."

Curvature: "No general rule can be given for determining the minimum radius of horizontal curvature. In mountain location curves of 100-feet radius are sometimes necessary,whereas in the flatter sections of the country curves of 1000-feet radius are the prevailing practice. The predominating minimum radius of curvature on Federal-aid projects has been about 500-feet."

Compound and reverse curves,frequently used in the past,are now recognized as being extremely dangerous for present day traffic. Where a reverse curve must be used a tangent section not less than 200-feet long,between the curves,will permit proper transition with superelevation and widening. Georgia requires the minimum tangent distance between curves to be 200-feet,and where the degree of curvature is 5° or more the tangent should be 300-feet. They require whenever practicable

Minimum Requirements for Surveys for Various Classes of Roads

	Coastal and Plains	Rolling and Hilly	Foothills and Mountains
	CLASS A	CLASS A	CLASS A
Width	30-35	30-35	30-35
Type	Concrete or asphalt	Concrete or asphalt	Concrete or asphalt
Curve	6 degrees	10 degrees	+30 degrees
Grade	5 per cent	7 per cent	8 per cent
Vertical curve	See Note "A"	See Note "A"	See Note "A"
Grading per mile	9,000 cu. yds.	15,000 cu. yds.	20,000 cu. yds.
Sight distance	500′	500′	300′
Distance between curves	500′	300′	140′
	CLASS B	CLASS B	CLASS B
Width	30-35	30-35	30-35
Type	Sand-asphalt, gravel Sand-clay or macadam	Sand-asphalt, gravel Sand-clay or macadam	Sand-asphalt. gravel Sand-clay or macadam
Curves	10 degrees	15 degrees	+50 degrees
Grade	5 per cent	7 per cent	8% (6% on curves of 30° (or over)
Vertical curve	See Note "A"	See Note "A"	See Note "A"
Grading per mile	6,000 cu. yds.	8,000 cu. yds.	15,000 cu. yds.
Sight distance	400′	300′	300′
Distance between curves	400′	200′	140′
	CLASS C	CLASS C	CLASS C
Width	24′	24′	24′
Type	Sand-clay, topsoil, Gravel or macadam	Sand-clay, topsoil Gravel or macadam	Sand-clay, topsoil Gravel or macadam
Curve	20°. See Note "B"	20°. See Note "B"	+60°. See Note "B"
Grade	5 per cent	7 per cent	8% (6% on curves of 40° (or over)
Vertical curve	See Note "A"	See Note "A"	See Note "A"
Grading per mile	5,000 cu. yds.	7,000 cu. yds.	9,000 cu. yds.
Sight distance	300′	300′	300′
Dist. between curves	200′	200′	140′

+NOTE=Curves of 3° and over to be spiraled, widened and superelevated.

NOTE A=Not less than 200′. Longer curves to be used if necessary to secure 300′ sight distance.

NOTE B=On Class "C" road curves may be reversed to reduce cost of grading provided central angles are small and sight distance is satisfactory.

GENERAL NOTE: Where the central angle is greater than 45° the lightest curve consistent with the allowable yardage should always be used.

TABLE 4

that the degree of curve be in whole numbers, as 3° or 5°, to avoid interpolation in widening and superelevation.

However in its instructions to Resident and Locating Engineers the Georgia Highway Department does not specify grades leaving each individual case to be handled on its merits. On the other hand South Carolina in its "Instructions to Locating Engineers" (1923) specifies that no grade in excess of 5% and no curve sharper than a 12° curve shall be used on main highways, except with the consent of the State Highway Engineer.

The present requirements of the Georgia Highway Department for vertical curves, which are based on a minimum sight distance of 500-feet, assuming the eye to be 5-feet above the road surface, are as follows:

Algebraic Difference of grades.	Length of Curve Required.
0.0 to 5.5	300 feet
5.5 to 6.0	350 feet
6.0 to 6.5	400 feet
6.5 to 7.0	450 feet
7.0 to 8.0	500 feet
8.0 to 8.75	550 feet
8.75 to 9.50	600 feet
9.50 to 10.25	650 feet
10.25 to 11.00	700 feet
11.00 to 12.00	750 feet
12.00 to 13.00	800 feet

The question of culvert location can be touched upon briefly, inasmuch as bridge location is treated separately, by stating that adequate vertical and horizontal clearance is essential. Location over swampy or soft foundation material; below a sharp bend or kink in the general stream alignment; at point of rapid fall or where stream may be diverted from its natural course during freshets; and skew crossings should be avoided.

Each individual problem must, of course, be treated individually and solved on its merits. The locating engineer

TABLE OF AREAS OF WATERWAYS CALCULATED BY TALBOT'S FORMULA.

$a = C\sqrt[4]{A^3}$ a = Area of waterway in square feet.
A = Drainage area in acres.

Drainage Area		Areas of Waterways in Square Feet						
		Mountainous Land	Hilly Land		Rolling Land		Flat Land	
Acres	Sq. mi.	C=1.00	C=.80	C=.60	C=.50	C=.40	C=.30	C=.20
1	.0016	1.0	.8	.6	.5	.4	.3	.2
2	.0031	1.7	1.4	1.0	.8	.7	.5	.3
4	.0062	2.8	2.2	1.7	1.4	1.1	.8	.6
6	.0094	3.8	3.0	2.3	1.9	1.5	1.1	.8
8	.0125	4.8	3.8	2.9	2.4	1.9	1.4	1.0
10	.016	5.6	4.5	3.4	2.8	2.2	1.7	1.2
15	.023	7.6	6.1	4.6	3.8	3.0	2.3	1.5
20	.031	9.5	7.6	5.7	4.7	3.8	2.8	1.9
30	.047	12.8	10.2	7.7	6.4	5.1	3.8	2.6
40	.062	15.9	12.7	9.5	8.0	6.4	4.8	3.2
60	.094	22	17.6	13	11	8.8	6.6	4.4
80	.125	27	21.6	16	13	10.8	8.1	5.4
100	.156	32	25.6	19	16	12.8	9.6	6.4
150	.234	43	34.4	26	21	17.2	12.9	8.6
200	.312	53	42.4	32	27	21.2	15.9	10.6
250	.39	63	50	38	31	25	19	13
300	.47	72	58	43	36	29	22	14
400	.62	89	71	53	45	36	27	18
500	.78	106	85	64	53	42	32	21
600	.94	121	97	73	61	48	36	24
800	1.25	150	120	90	75	60	45	30
1,000	1.56	178	142	107	89	71	53	36
1 500	2.34	241	193	145	121	96	72	48
2,000	3.12	299	239	179	149	120	90	60
2,500	3.91	354	283	212	177	142	106	71
3,000	4.7	405	324	243	203	162	122	81
4,000	6.2	503	402	302	252	202	151	101
5,000	7.8	595	476	357	297	238	179	119
6,000	9.4	682	546	409	341	273	205	136
8,000	12.5	846	677	508	423	338	264	169
10,000	15 6	1,000	800	600	500	400	300	200
12,000	18.8	1,147	918	688	573	459	344	229
14,000	21.9	1,287	1,030	772	644	515	386	257
16,000	25.0	1,423	1,138	854	711	569	427	285
18,000	28.1	1,554	1,243	932	777	622	466	311
20,000	31.2	1,682	1,346	1,009	841	673	505	336
25,000	39.1	1,988	1,590	1,193	994	795	596	398
30,000	47.0	2,280	1,824	1,368	1,140	912	684	456
40 000	62.0	2,828	2,262	1,697	1,414	1,131	848	566
50 000	78.0	3,344	2,675	2,006	1,672	1,338	1,003	669
60,000	94	3,834	3,067	2,300	1 917	1,534	1,150	767
70,000	109	4,304	3,443	2,582	2,152	1,722	1,291	861
80,000	125	4,757	3,806	2,854	2,378	1,903	1,427	951
100,000	156	5,623	4,498	3,374	2,812	2,249	1,687	1,125
125,000	195	6,648	5,318	3,989	3,324	2,659	1,994	1,330
150,000	234	7,622	6,098	4,573	3,811	3,049	2,287	1,524
175,000	273	8,556	6,845	5,134	4,278	3,422	2,567	1,711
200,000	312	9,457	7,566	5,674	4,728	3,783	2,837	1,891
300,000	469	12,819	10,255	7,691	6,410	5,128	3,845	2,564
400,000	625	15,905	12,724	9,543	7,952	6,362	4,772	3,181
500,000	781	18,803	15,042	11,282	9,402	7,521	5,641	3,761
600,000	937	21,558	17,246	12,935	10,779	8,623	6,467	4,311
800,000	1,250	26,750	21,400	16,050	13,375	10,700	8,025	5,350
1,000,000	1,562	31,623	25,298	18,974	15,812	12,649	9,487	6,325
1,200,000	1,875	36,256	29,005	21,754	18,128	14,502	10,877	7,251
1,400,000	2,188	40,700	32,560	24,420	20,350	16,280	12,210	8,140
1,600,000	2,500	44,987	35,990	26,992	22,494	17,995	13,496	8,997
1,800,000	2,813	49,142	39,314	29,485	24,571	19,657	14,743	9,828
2,000,000	3,125	53,183	42,546	31,910	26,592	21,273	15,955	10,637
2,200,000	3,438	57,124	45,699	34,274	28,562	22 850	17,137	11,425
2,400,000	3,750	60,976	48,781	36,586	30,488	24,390	18,293	12,195
2,600,000	4,063	64,748	51,798	38,849	32,374	25,899	19,424	12,950
2,800,000	4,375	68,449	54,759	41,069	34,225	27,380	20,535	13 590
3,000,000	4,688	72,084	57,667	[illegible]	36,042	28 834	21,6[illegible]	14,417
3,200,000	5,000	75,659	60,527	45,395	37,830	30,264	22,698	15,132

TABLE 5

should run out and list all drainage areas with his recommendations for each. Table 5 is a chart in use by the Georgia Highway Department which gives the area of opening required for various drainage areas, in different types of country, based on Talbots formula.

T H E   S U R V E Y

FIG. IX

View of U.S.1 between Washington and Richmond. Showing relocation in Virginia preparatory to widening present 18'pavement to permit 3 lanes of traffic by widening on one side where the alignment is satisfactory. All blind and hazardous curves were improved by short relocations as illustrated above.

THE SURVEY

The Survey Party generally consists of the Locating Engineer as Chief of Party, with a party made up of Instrumentman, Rodmen, Chainmen, and when required Axemen. Since the detailed organization and duties are covered in various Handbooks there will be no need to go into detail in this paper.

The Survey Party is usually divided into two sections, viz: The transit party and the level party. The transit party will generally handle all topography notes as it goes along, and the two parties may be combined at intervals to take cross-sections or some special topography, etc.

The engineering operations requisite to the highway survey are: The Reconnoissance, The Preliminary Survey, and The Location. Some engineers carry their final location along with their preliminary location. This can only be done after years of experience, and once mastered properly will save much effort and cost in making a location.

The Reconnoissance is a general and somewhat hasty examination of the country, thru which the road is to pass, for the purpose of noting its more prominent features, and acquiring a general knowledge of its topography with reference to the selection of a suitable route.

This work calls for a high degree of engineering skill and broad vision, as the engineer must be able to visualize the completed highway carrying thousands of vehicles with the greatest possible facility, safety, and economy. It is here that the two primary requisites for a Locating Engineer come into play - these requisites being the ability to judge distance and direction with ease and an uncanny accuracy. I have accompanied a man, who has an enviable record as a locating engineer, for great distances ahead of the transit party, both in the mountains and over winding roads, and have had him point out a tree or some prominent terrain feature and tell me we should pass within so many feet of that object; then go back to the transit party and turn an angle that would eventually bring us by the very point mentioned. Except in extremely rough country, or some unusual circumstance, he was able to avoid running a preliminary line, utilizing his ability to observe and judge distance and direction during the reconnoissance to place his final location where it should be.

Most engineers pay little heed to the reconnoissance and tho they may locate a good line thru the country traversed, it is not always the best line between the terminal points. They also overlook another most important point in the reconnoissance and that is to obtain and study any available map of the country in question. The U.S. Geological Survey maps, on a scale of a mile to the inch, are particularly valuable since their contour lines show elevations. The maps of the U.S. Coast and Geodetic Survey, of the U.S. Engineer (War) Department, and soil maps of the U.S. Department of Agriculture and the local State College of Agriculture are all valuable supplements where no Geological Survey map is available.

The use of such maps saves needless field trips; affords and idea of routes and grades thereon; serve as a check on the actual field operations; and quickly determines what routes should be discarded.

Where no maps are available of the section desired, as is true for a large portion of the State of Georgia, it will be necessary that the engineer travel over the most favorable routes,and if required,by reason of the peculiar topography,he must cover the entire country between the terminal points;so that he can choose a route which can be built at a reasonable cost, all factors considered,and which can be maintained economically.

The engineer should not only seek the best ground on the route first assumed,but should have an eye to all other possible routes,holding them in consideration pending this accumulation of evidence and being ready,finally,to adopt that one which promises the greatest ultimate economy. He should be able to read the face of the country like a book or map,and to carry in his mind a continuous idea or image of any line he is examining,so as to judge with tolerable accuracy of the influence any one portion of the line may have on another as to alignment and grade,even tho many miles apart.

At the present time the use of aerial photographs and maps on reconnoissance are coming more and more into use. In any map with accurate contours the trained and competent locating engineer has a valuable tool. He will be able to adopt the most suitable alignment from noting the direction of streams,wooded areas,height and formation of slopes,direction and position of ridges,and the location and elevation of various passes.

The actual survey operations are well covered in all manuals dealing with highway and railroad curves,and in treatises on surveying,so will not be discussed here.

When the engineer finds it necessary to run a preliminary line he will usually "hub" it out,i.e.,place only sufficient stakes to give the necessary P.O.Ts.(Points on Tangent). In securing elevations the Locke,or hand,level and target rod are most frequently used.

Some engineers make their final location by plotting it on a contour map secured from the preliminary survey. If the preliminary survey has been made at the proper location there is no objection to this method. Where the location can be made directly without the use of the contours much labor and time can be saved.

It is advisable at this point to offer a few cautions regarding the conduct of the survey. Foremost may be mentioned the adjustment of the instruments before the start of the survey, and at frequent intervals during the survey especially after a rough trip or usage. The rodman should be cautioned to always hold his rod plumb,in order to counteract the natural tendency to cant the rod. The chain should be held taut to counteract any tendency to allow it to sag. All members of the party should carry keel(lumber crayon),and tacks with them at all times.

Hubs should be solid stakes,preferably of heart material approximately two inches square,driven solidly into the ground with a tack driven in top to mark the point on the line. These hubs are frequently a short piece of iron pipe with a wooden plug driven in it to hold the tack. Theyshould be permanent in so far as possible,and should always be reference by means of a guard stake,showing the stationing,driven alongside them.

Where the location follows an old road nails (about 7") should be driven in the ground to mark stations or hubs. If the latter a hole should be dug in the road about 6" deep and a nail driven thru a Coca Cola bottle cap to mark the point. All stakes should show the station number and offset on them. These stakes should then be driven,at right angles to the line,off the road to act as reference and guard stakes. It is preferably when offsetting stakes to offset them on the same side of the center line thruout. Care should be taken to see that the stakes are measured and driven at right angles to the center line when offset. If a guard stake for a hub it should be so noted on back of the stake by writing P.O.T.;P.O.C.;etc.

Where it is necessary to make an equality in line,this should be clearly shown by giving the station forward equals the station back,as: Sta.156+25.6 Forward = Sta.156+32.8 Back which is a minus equality of 7.2 feet,if one subtracts the difference but in reality the line is 7.2 feet longer due to the equality. An equality in levels is shown similarly.

It is well to stress the fact that accuracy in levels is of more importance than is accuracy in distance. Next in importance comes accuracy in reading angles on the vernier of the transit. An error in levels or angle may possibly result in changing a location,but an error in distance can be corrected on construction. This can be seen when it is realized than an angle of 1° subtends achord of 1.75' in 100';and that an error in levels of one foot may result in a difference of gradient sufficient to adversely affect a line. Thus it can be seen that this later is the most serious error.

The procedure of the survey party is relatively simple and follows good survey practice,so shall not be touched upon here. The Locating Engineer will usually be with the transit party and gives the transitman instructions regarding all turns that are made. He is thus enabled to place the alignment where desired.

In order to simplify and coordinate its surveys the Georgia Highway Department requires that they shall begin at the south or west end.

TABLE FOR CALCULATING CURVES WHEN D IS 18°00 OR MORE

Degree	Radius	$\pi R \div 180$	Def. 1 ft.	Def. 25 ft.
18	319.62	5.57842	5.38′	2°–14.5′
19	302.94	5.28730	5.67′	2°–21.7′
20	287.94	5.02550	5.97′	2°–29.2′
21	274.37	4.78867	6.26′	2°–36.5′
22	262.04	4.57346	6.56′	2°–44.0′
23	250.79	4.37711	6.85′	2°–51.2′
24	240.49	4.19734	7.15′	2°–58.7′
25	231.01	4.03188	7.44′	3°–06.0′
26	222.27	3.87934	7.73′	3°–13.2′
27	214.18	3.73814	8.03′	3°–20.7′
28	206.68	3.60724	8.32′	3°–28.0′
29	199.70	3.48542	8.61′	3°–35.2′
30	193.19	3.37180	8.90′	3°–42.5′
32	181.40	3.16602	9.48′	3°–57′
34	171.02	2.98487	10.05′	4°–11.2′
36	161.80	2.82394	10.62′	4°–25.5′
38	153.58	2.68047	11.19′	4°–39.8′
40	146.19	2.55149	11.76′	4°–54′
42	139.52	2.43508	12.32′	5°–08′
44	133.47	2.32949	12.88′	5°–22′
46	127.97	2.23350	13.43′	5°–35.8′
48	122.93	2.14553	13.98′	5°–49.5′
50	118.31	2.06490	14.53′	6°–03.2′
52	114.06	1.99072	15.07′	6°–16.8′
54	110.11	1.92178	15.61′	6°–30.2′
56	106.50	1.85877	16.14′	6°–43.5′
58	103.13	1.79996	16.67′	6°–56.8′
60	100.00	1.74533	17.19′	7°–09.8′
63°–31′	95	1.65806	18.09′	7°–32.3′
67°–30′	90	1.57080	19.10′	7°–57.5′
72°–04	85	1.48353	20.22′	8°–25.5′
77°–22′	80	1.39625	21.49′	8°–57.3′
91°–10′	70	1.22173	24.56′	10°–14′
180°	50	0.87266	34.38′	14°–19.5′

Example

Given $\Delta = 72°\text{–}36'$ $D = 34°\text{–}00'$

$$Lc = \frac{\pi R \Delta}{180} = \frac{\pi R}{180} \times 72.6$$

From Table $\dfrac{\pi R}{180} = 2.98487$

$Lc = 2.98487 \times 72.6 = 216.7$

$T = R \operatorname{Tan} \tfrac{1}{2}\Delta = 125.6$

TABLE 6

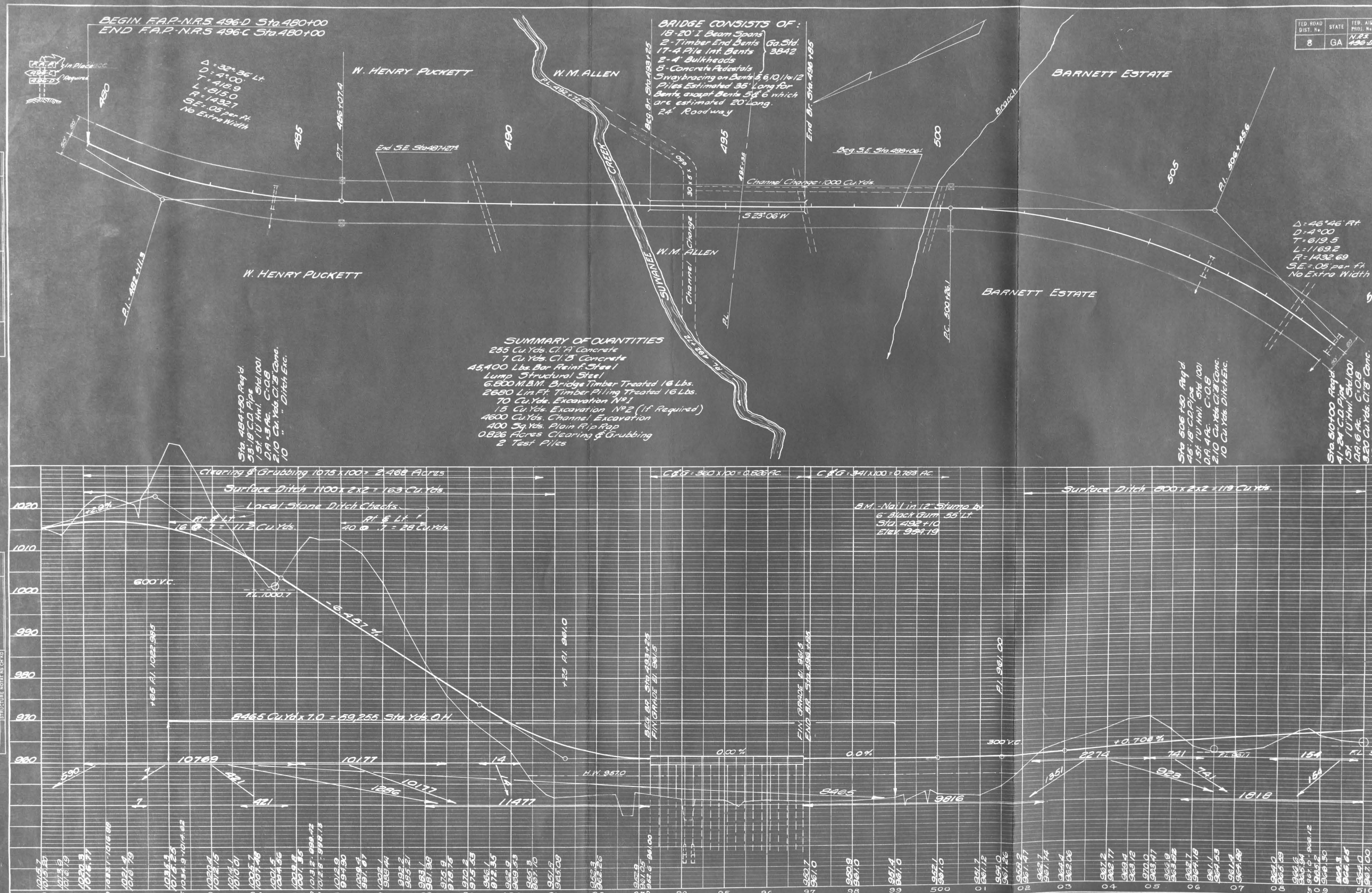
When starting the survey the zero hub of the transit line, and all other control points, should be referenced to three or more permanent objects if possible, so that the line may be definitely re-run several years later without depending on stakes-which are at best only temporary. A solar observation should be made at the begining and ending of each survey to serve as a check on the alignment. If calculated bearings are checked against magnetic bearings after each turn, any error will be caught.

Stakes must be driven at P.Cs. and P.Ts., and at 100-ft. intervals on tangents except where breaks occur when a stake is driven to mark the station-plus of the break. This is especially true at the banks of streams and ditches so that there will be no chance of failure to secure elevations and cross-sections at these points. Stakes will be driven at 100-ft. intervals on curves of less than 4°; at 50-ft. intervals from 4° to 12°; and over this at 25-ft. intervals. In mountain locations it is frequently necessary to run in and stake out the curve on chords of less than 25-feet.

All text on surveys show a specimen page of the transit notes with the data required. Fig.X illustrates a plan sheet plotted from the transit notes. The data required can be summed up by stating that in addition to the curve data, all topography within 500-feet of each side of the center line should be shown.

When measuring the off-set to buildings, etc. care must be exercised to see that all measurements are made perpindicular to the center line. This is particularly true on curves.

To illustrate the care required in taking notes: I have seen a set of notes come in from the field in which the end of the survey was shown at a different station, varying by several


BEGIN F.A.P.-N.R.S. 496-D Sta. 480+00
END F.A.P.-N.R.S. 496-C Sta. 480+00
Δ = 32° 36' Lt.
D = 4° 00'
T = 418.9
L = 815.0
R = 1432.7
S.E. = .05 per ft.
No Extra Width
W. HENRY PUCKETT
W. M. ALLEN
BRIDGE CONSISTS OF:
18-20' I Beam Spans
2-Timber End Bents
17-4 Pile Int. Bents
2-4' Bulkheads
8-Concrete Pedestals
Swaybracing on Bents 5, 6, 10, 11 & 12
Piles Estimated 35' Long for Bents, except Bents 5 & 6 which are estimated 20' Long.
24' Roadway
Ga. Std. 3842
BARNETT ESTATE
End S.E. Sta. 487+27
Beg. S.E. Sta. 499+06
Channel Change - 1000 Cu. Yds.
S 23° 06' W
SUWANEE CREEK
Channel Change
W. M. ALLEN
W. HENRY PUCKETT
BARNETT ESTATE
Branch
P.I. 482+11.3
P.T. 486+07.4
P.C. 500+26.1
P.I. 506+45.6
Beg. Br. Sta. 493+25
End Br. Sta. 496+85
Δ = 46° 46' Rt.
D = 4° 00'
T = 619.5
L = 1169.2
R = 1432.69
S.E. = .05 per ft.
No Extra Width
SUMMARY OF QUANTITIES
255 Cu. Yds. Cl. "A" Concrete
7 Cu. Yds. Cl. "B" Concrete
45,400 Lbs. Bar Reinf. Steel
Lump Structural Steel
6.800 M.B.M. Bridge Timber Treated 16 Lbs.
2680 Lin. Ft. Timber Piling Treated 16 Lbs.
70 Cu. Yds. Excavation No. 1
15 Cu. Yds. Excavation No. 2 (If Required)
4600 Cu. Yds. Channel Excavation
400 Sq. Yds. Plain Rip Rap
0.826 Acres Clearing & Grubbing
2 Test Piles
Sta. 484+50 Req'd. 33-18" C.D. Pipe 1 St. 1 U Hwl. Std. 1001 D.A. 3 Ac. C: 0.8 2.10 Cu. Yds. Cl. B Conc. 10 " " Ditch Exc.
Sta. 506+60 Req'd. 46-18" C.D. Pipe 1 St. 1 U Hwl. Std. 1001 D.A. 4 Ac. C: 0.8 2.10 Cu. Yds. Cl. B Conc. 10 Cu. Yds. Ditch Exc.
Sta. 510+00 Req'd. 41-24" C.D. Pipe 1 St. 1 U Hwl. Std. 1001 D.A. 6 Ac. C: 0.8 3.20 Cu. Yds. Cl. B Conc. 10 Cu. Yds. Ditch Exc.
FED. ROAD DIST. No. 8
STATE GA
FED. AID PROJ. No. N.R.S. 496-D
PLAN
PROFILE
Clearing & Grubbing 1075 x 100 = 2.468 Acres
Surface Ditch 1100 x 2 x 2 = 163 Cu. Yds.
Local Stone Ditch Checks
Rt. & Lt. 16 @ .7 = 11.2 Cu. Yds.
Rt. & Lt. 40 @ .7 = 28 Cu. Yds.
C.&G. = 360 x 100 = 0.826 Ac.
C.&G. = 341 x 100 = 0.783 Ac.
Surface Ditch 600 x 2 x 2 = 119 Cu. Yds.
B.M. - Nail in 12" Stump by 6" Black Gum 55' Lt. Sta. 492+10 Elev. 984.19
600' V.C.
P.I. 1000.7
-6.457%
+85 P.I. 1022.985
+25 P.I. 961.0
BEG. BR. Sta. 493+25 FIN. GRADE El. 961.0
FIN. GRADE El. 961.0 END BR. Sta. 496+85
P.I. 961.00
300' V.C.
0.00%
0.0%
+0.708%
H.W. 957.0
8465 Cu. Yd. x 7.0 = 59,255 Sta. Yds. O.H.
10769
10177
11477
8465
9816
2274
1818
1020
1010
1000
990
980
970
960
480
81
82
83
84
85
86
87
88
89
490
91
92
93
94
95
96
97
98
99
500
01
02
03
04
05
06
07
08
09
510
PLATE 1 - PLAN - PROFILE

hundred feet, in each of the transit, level, and cross-section books. It is rare that sufficient data for stream crossings, and structures in place, are shown - thus necessitating their return to the field for further information.

When starting the line of levels it is generally customary to place a Bench Mark (B.M.) near the zero hub. This B.M. should be placed on some permanent object, and tied in to some known Bench. Such a Bench will be on another survey, a Government Bench, or if in a city a nearby fireplug. If no known Bench is available then an assumed elevation, based on the approximate datum of the immediate locality, is taken for the starting B.M.

Where Government B.Ms. are available at the begining and ending of a survey they can be used in lieu of check levels; otherwise it is the practice of the Georgia Highway Department to run a line of check levels, during the course of the survey.

Bench marks should be selected with care, and so placed that they will not be destroyed by construction operations. This applies with great force to the bench mark placed near each major stream crossing. Fig.X illustrates a line of profile levels plotted up, and shows the descriptions of the various B.Ms.

Levels and cross-sections should be taken at all full stations established on the transit line, as well as all abrupt breaks in the terrain. On reconstruction work it may be found necessary to take elevations at intervals of 25-ft. or less in order to permit the new grade to fit the old.

Profile levels should show elevations of: all pipe lines and manholes, tops of rails of intersecting tracks, of all intersecting roads for at least 150-ft. from the center line, ground elevations of all buildings that might affect the grade, and

B.M.	0.55	200.55		200.00	Tp.Fireplug 48' lt.Sta.0+47
0+00		2.75		197.8	
+42.3		2.98		197.57	
1+00		5.2		195.3	
2+00		9.8		190.7	
+09		10.05		190.50	End Paving
T.P.	1.11	191.60	10.06	190.49	
3+00		6.1		185.5	
+70		7.3		184.3	
4+00		7.9		183.7	
5+00		5.6		186.0	
6+00		4.4		187.2	
T.P.	0.43	189.10	2.93	188.67	
7+00		1.4		187.7	
8+00		2.9		186.2	
9+00		4.5		184.6	
10+00		4.8		184.3	
+20		7.6		181.5	
T.P.	10.80	197.48	2.42	186.68	
11+00		9.6		187.9	
B.M.			6.98	190.50	Nail in 24"China-berry 60'Rt.14+50
Check	12.89		22.39		

Check:

-22.39	200.00
+12.89	190.50
9.50✓	9.50✓

Left Hand Page - Right Hand Page

FIG. 7

Typical Sheet of Level Notes.

clearance of overhead structures,or any other elevation that may affect design or construction.

Either the level or transit notes should show location and recommendations for all drainage structures and cross-drain pipe. The specifications of the Georgia Highway Department classifies any opening with a clear span of 20-feet or over as a bridge. The data required for all drainage structures are similar and should be shown in the notes.

The profile notes should give sufficient elevations to show grade,height of opening,and depth of water at all bridges,culverts,streams and gullies. In all cases it is of utmost importance to show the elevation of HIGHWATER. In listing the highwater elevation the date and source from which it is determined should be stated. The year in which highest known highwater occurs varies with the stream and section of the state.

Where the transit line is on an offset to the true center line,in order to avoid some obstacle,the levels and cross-sections should always be taken on the true center line,or else a notation made that this was not done with sufficient information given to aid in determining the true center line elevations.

The level party should at all times be as close to the transit party as is feasible,considering the terrain traversed. It will frequently be found necessary to have the levels up in order to determine the gradient before the transit party can proceed.

Before taking cross-sections the engineer should know the width of roadway,berms and ditches,and also the slopes to be used on the project. These items will vary depending on the type of road and its construction,and the State and section of State.

Left Hand Page				Right Hand Page			
0+00	-0.8 40.0	-1.0 30.0	-1.9 23.0	0.0	-0.8 21.0		-1.0 40.0
+42.3	+0.4 40.0	0.0 33.0	-1.3 28.0	0.0	-1.0 27.0	-0.7 28.0	00 40.0
2+00	-0.4 40.0			0.0			0.0 40.0
3+00	-5.5 40.0	-5.7 31.0	-0.7 30.0	0.0	-0.6 17.0	-5.9 20.0	-6.1 40.0

FIG.8

A Typical Method of Keeping Cross-Section Notes

In this case the Locke Level is used and the H.I. is constant so that it will be deducted from each rod reading before being recorded. The elevation of the center line is shown by a rod reading of zero in all cases - the elevation being the same as recorded in the level notes. The elevation of the other distances are therefore found by adding or subtracting the rod readings shown from the center line elevation.

Cross-sections should be taken at all points that a level reading has been taken,and to avoid missing any point the stations of all rod readings should be copied from the level book into the cross-section book prior to cross-sectioning. Where feasible they should be taken for full width of right of way,and in all cases should be taken far enough on each side of center line to permit plotting the roadway grade on them.

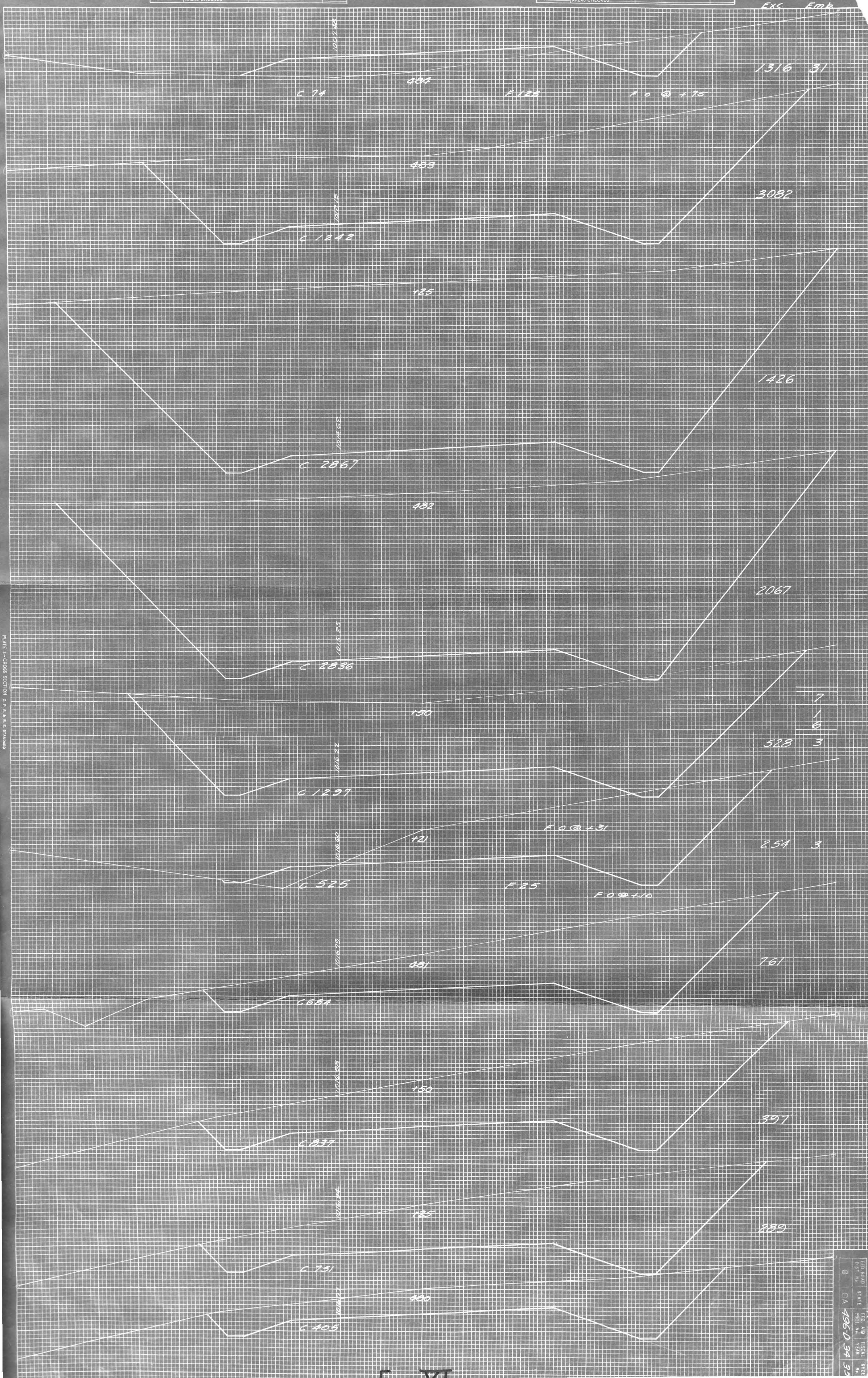
The organization of the cross-section party is variable depending on men available and preference of Chief of Party. It will consist ordinarily of an instrumentman and two or more rod-men. It is the general practice in Georgia,and probably most States,to use the Locke or hand level rather than the "Y" level in taking cross-sections. When this is done it is customary to place the level on a 5-ft.stick when reading in order to maintain a constant H.I. The center line reading will then be 0.0 and the other readings plus or minus the difference in elevation between the rod and center line. Distances should always be written as 10.0 if even feet or 10.4 if odd feet to avoid confusion in reading notes. The readings will be written as a fraction with the elevation as the numerator and the distance as the denominator,thus: +1.3/7.5 . Fig.XI is a typical plan cross-section sheet.

Altho the Locating Engineer rarely has to figure earthwork quantities from cross-sections,it is worthwhile for him to know the methods used on construction for figuring yardage. In the office this is done by means of a planimeter set to read cubic yards direct. This is not feasible in the field so more direct methods are employed. Two of these methods are the "Criss-Cross" or Double Area method and the Double Triangular Formula.

To illustrate the Criss-Cross method let us assume that

ORIGINAL SURVEY		BY	DATE
	SURVEYED		
	PLOTTED		
NOTE BOOK	TEMPLATE		
	AREAS		
NO.	AREAS CHECKED		

FINAL SURVEY		BY	DATE
	SURVEYED		
	PLOTTED		
NOTE BOOK	TEMPLATE		
	AREAS		
NO.	AREAS CHECKED		



the roadway template has been plotted on the cross-sections, and using Sta.482+00 of Fig.XI as an example we assume the notes to be

$$\frac{0.0}{50.0} \quad \frac{-19.0}{26.0} \quad \frac{-19.5}{24.0} \quad \frac{-19.5}{0.0} \quad \frac{-19.6}{25.0} \quad \frac{-20.0}{32.0} \quad \frac{0.0}{50.0}$$

which in this case would represent the readings for setting slope stakes. Then crisscrossing from left to right, first numerator times denominator then denominator times numerator, and adding the two then dividing by 2 gives us the yardage for the single area underconsideration. We thus have:

0.0 x 26.0 = 0.0	50.0 x 19.0 = 950.0
19.0 x 24.0 = 453.0	26.0 x 19.5 = 507.0
19.5 x 0.0 = 0.0	24.0 x 19.5 = 468.0
19.5 x 25.0 = 487.5	o.o. x 19.6 = 0.0
19.6 x 32.0 = 627.2	25.0 x 20.0 = 500.0
20.0 x 50.0 = 1000.0	32.0 x 0.0 = 0.0
2567.7	2425.0

and adding them together and dividing by two we get 2294.8 cu.yds. and if we add the side ditches estimated to be 381.5 we have a total of 2676.3 cu.yds. which checks reasonably close with the yardage shown on Fig.XI. It is well to mention that the ditches will give a constant thruout the use of the same ditch section.

The triangular method is very similar except that the cut or fill is figured as a rectangle and the two end triangles, formed by the slopes, are subtracted from the total double area found and the result divided by 2, as above, to find area of the section at station considered. The total earthwork may then be found by adding two sections as in the double end area method.

It is common practice for the locating engineer to keep, and submit with his notes, a "continuous profile" of his location. This consists of a roll of special paper printed with cross section lines on one side to permit plotting the profile, and white on the other to permit plotting the alignment and topography. This permits the entire line to be plotted up on one continuous sheet with tentative grades and alignment shown to a scale of,usually,400 feet to the inch horizontally,and 20 feet to the inch vertically.

In laying grades most engineers use a straight edge, but I have observed that most of the more experienced locating engineers,in Georgia,use a spool of strong black thread;when laying grades in the field. This offers many advantages,for it is convenient and its color offers a strong contrast with the profile,besides not covering any part from view. It may be easily shifted,or with the aid of several pins more than one grade can be studied at the same time.

Altho the question of grades has been rather thoroughly discussed previously,it is well to bear in mind two primary objectives when laying grades. These are;first,that whenever possible quantities should balance,that is,earthwork from cuts should be used to make the fills so that borrow and waste can be reduced to a minimum;and secondly,to secure easy grades. In mountain location it is preferable to have a break in grades so as to furnish a breather space for vehicles.

Vertical curves can be computed as follows: The elevation on the curve equals the straight grade elevation,plus or minus distance on curve squared,divided by half the length of curve,squared,times the middle ordinate. This may be shown by the formula: $e' = e \pm [(d'/\frac{1}{2}l)^2 \times M]$ where e'= elevation on curve, e= straight grade elevation, d' = distance, l = length of curve,and M = middle ordinate. The Middle Ordinate being equal to the algebraic difference in gradient,times Stations in curve, divided by 8, $M.O. = (-A-B)xS/8$.

There are many curve tables published,and in use, which give constants for various distances from the P.C. or P.T. which,when multiplied by the middle ordinate,will give the factor to be added or subtracted from the straight grade elevation to give the elevation of the curve at that point.

In the field vertical curves may be easily calculated by the use of a Polyphase Slide Rule for computing corrections as follows: Set the slide on middle ordinate on scale A;set half the length of curve on scale C on slide;run slide to distance on scale C,and read correction on scale A.

Understanding the above field procedure we can better understand what the Locating Engineer must decide upon,and direct,in the actual survey operations. We find that in his reconnoisance he must tentatively locate the road both in his own mind and on any maps he might possess - that he must decide whether his survey will be a ridge line,valley line,or whether in mountain work he can locate a suitable pass.

We find that he must frequently make a preliminary survey to: Fix accurately the maximum grade to be used; determine which of several lines is best;provide a map as a basis upon which the location can be properly made;and to make a close estimate of the cost of the work; before he can proceed with the final location or the final fitting of the line to the ground.

Before transmitting notes to the office,the Chief of Party should see that all sheets and notes are arranged consecutively,pages numbered,books indexed and dated,and all computations made and carefully checked.

B R I D G E   L O C A T I O N

BRIDGE LOCATION

Some States have a special survey party to determine the location for all large bridges,however the majority,like Georgia,follow the location established by the locating engineer and check the site for design purposes only,or to take more elaborate soundings for foundation design.

The burden of bridge location falls,therefore,on the Locating Engineer who,in locating a road,must cross a stream or railway requiring a bridge. Few locating engineers know or realize the data required to properly design a bridge;and seldom send in a set of notes with sufficient data to permit the bridge department to make up a design,without first obtaining additional information from the field. As an example I saw a set of notes which consisted of the following data at the bridge location: "Branch with good flow." Incidentally this branch required a 100-foot bridge.

In crossing a stream,where possible,the survey should cross at right angles to the center line of the stream. The crossing should be on a straight reach of the stream between high well established banks or bluffs,and not in the bend of the stream or at a point where it is likely to change its channel in periods of highwater. The narrowest crossing should be sought at all times,unless other data outweigh the consideration of length. This should be determined by a reconnoissance of the stream,for some distance above and below the tentative center line,before the survey reaches it.

In general the location should be such that sharp curves in the alignment will not be introduced near the ends of the bridge tangent. A location that would require a heavy grade on the structure should be avoided whenever possible. When grades are laid ample allowance should be made for clearance between the bottom of the trusses,or girders,and the floor,and also for the required clearance above highwater. It is the practice of the Georgia Bridge Department to allow 1.5-ft.clearance between the lowest beam,or girder,and highwater. Consideration must be given to clearance to allow for passage of drift,also.

The center line should be carefully referenced so that it may be readily found when the bridge is staked out. Bench marks should be definitely located and accurately described. The datum of the B.M. should be stated,if from a government bench it should also be described.

A traverse of the stream for a distance of 500-feet each side of the location center line should be made so that its general course can be determined. Where a channel change can be made to advantage,it should be shown. The topography of the stream should include all islands,shoals,other structures,and all works of man in the immediate vicinity of the proposed crossing. The bearing of the stream and its direction of flow should also be noted.

As mentioned under culvert location,the elevation of low water,normal water,and extreme highwater,are of utmost importance;and should be determined and shown. For navigable streams,the mean or average high and low tides should be determined;and care taken to see that these levels check the datum of the U.S.Geological Survey,whose datum is average tide,or the Coast and Geodetic Su rvey,whose datum is mean low tide. Where the datum used is a U.S. Engineer Department guage its datum must be checked,for instance on the Savannah River,Georgia,they have established a line of levels based on the Pulaski guage,which datum is established at old Fort Pulaski,near Savannah.

When practicable the velocity of the current,in feet per second,at high and normal water should be made by any means available. Any evidence of erosion by the stream,particularly along the banks,should be recorded as such evidence affects the layout of the structure. The amount and character of drift and ice should be determined and noted.

At locations over tidal streams,it is important to know whether or not the water is brackish. Nearby existing structures should be examined to see if there is any evidence of the presence of the teredo.

There is no exact method of determining the proper waterway. For instance in the mountains streams are very flashy and have a quick run-off so that a smaller opening on a steep slope will suffice,rather than a large opening on a small slope as is used in more level country. Judgement should be based on the following approximations: (1) Comparison with existing bridges; (2) computation by formula of the discharge of the natural channel,as shown by Table 5; and (3) estimate of the runoff from the drainage area. The last two methods do not give the waterway directly,but only the discharge for which it is necessary to provide. An opening must then be proportioned so that the discharge may be passed without damage to the structure.

The foregoing shows the lack of definiteness which characterizes waterway determinations and should emphasize the importance of complete and reliable data,so that all information will be at hand for applying a given method of computation,and further,that several methods may be compared.

Existing bridges near the proposed site should be measured, so that the area of the waterway below them may be determined. The measurements should be sufficient to show a layout of the bridge, elevation of the bridge floor, and elevation of high water with reference to the floor and lowest member, and the horizontal clearance over the channel when a navigable stream. The distance of the existing bridges above or below the proposed site should be noted, and also, it should be ascertained whether or not the adjacent roadway is inundated by high water.

All dams near the proposed site should be located and shown on a map accompanying the survey notes. If the bridge crosses above the dam, a typical cross-section of the stream below should be made to assist in determining the actual waterway required by the bridge; as a consideration of the profile thru the mill pond, alone, would be misleading. For the same reason it should be noted whether high water is caused by back water from larger adjacent streams. As mentioned previously the area of the drainage basin above the proposed crossing should be given.

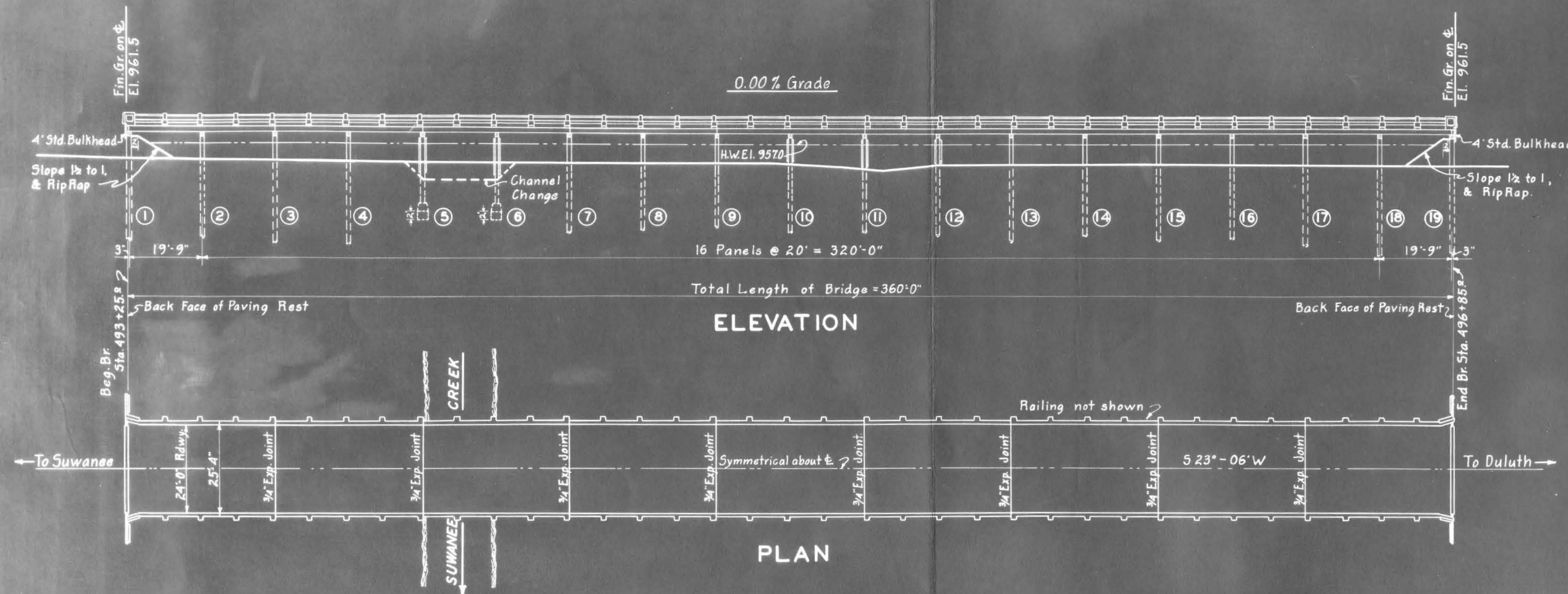
Preliminary investigations should be made to determine the depth and suitability of foundation material. Where rock is not present, or is at some depth below the ground surface, sounding rods, augers and, where special equipment is available, wash borings should be used to determine the character of the foundations; and all of the area which is likely to be included by a bridge structure should be explored. Other material besides rock, such as a deep bed of gravel or firm clay, may be considered adequate for foundations and the depth at which they occur should be indicated on the soundings with the type of material overlaying it.

The soundings should be carried to a depth sufficient to insure against incorrect footing design. The selection of the type of structure may depend largely upon the information submitted concerning the nature of the foundation soil. The depth to which soundings should be taken will be governed by the nature of the material encountered and the type of sounding equipment used. Rarely will a locating party be equipped with more than a makeshift sounding rod,and they will show as complete soundings as they possibly can to allow preliminary studies to be made.

Where the survey is a relocation and it is contemplated using an existing structure,or replacing it by a new structure on the old center line,it will be necessary to secure complete details of the existing structure. Where no plans are available,and it is contemplated widening or strengthening the existing structure,it may be necessary to take measurements of the structure in the field and draw it legibly in the note book to approximate scale - however,in a large structure,this is usually turned over to a special party out of the bridge engineers office and is rarely undertaken by the locating party. They will,however,show such information as a sketch of the structure showing major vertical and horizontal dimensions,clearance above high water and over channel,and when possible to secure from name plate or other source the date it was built,and by whom.

The locating party should show details of construction and materials used;evidence of scour,backing up or overflow; direction of flow;complete informatation regarding high water stages and dates;effect of natural forces as salt water,etc.; temperature and settlement on the action and life of the bridge; elevation of top of floor,bottom of stringers or floor beams,

FED. ROAD DIST. No.	STATE	FED. AID PROJ. No.	STATE AID PROJ. No.	FISCAL YEAR
8	GA.	NRS 496-D		1934



GENERAL NOTES:

Specifications: Georgia Standard.
RipRap slopes of fills at ends of bridge thoroughly.
Omit drains in decks directly over riprapped slopes.
Two Test Piles to be driven as directed by the Engineer. Payment for this item to be made at a unit bid price per pile.
If piling can be driven so as to secure 10' penetration, pedestals shall be omitted in Bents 5 and 6.
Excavation No. 1 to bottom of pedestals as shown.
Excavation No. 2 below bottom of pedestals as shown, if required.
Bottom of pedestals shown approximately only.
Carry all foundations to depth satisfactory to the Engineer.
For all other General Notes see Georgia Standard No. 3842.

BRIDGE CONSISTS OF:

18-20' I BEAM SPANS –
2-TIMBER END BENTS –
17-4 PILE INT. BENTS –
2-4' BULKHEADS –
8-CONCRETE PEDESTALS –
} GEORGIA STANDARD Nº 3842

SWAYBRACING ON BENTS 5, 6, 10, 11 and 12.
PILES ESTIMATED 35' LONG FOR All BENTS, EXCEPT BENTS 5 & 6 WHICH ARE ESTIMATED 20' LONG.

DRAINAGE DATA:

Drainage Area = 50 square miles.
Talbots Formula - C = 0.7
Area Opening Under H.W. = 1764 square feet.

DESIGN DATA:

Typical H-15 Loading
Impact Allowed

SUMMARY OF QUANTITIES:

255 CU. YDS. CLASS "A" CONCRETE.
7 CU. YDS. CLASS "B" CONCRETE.
45,400 LBS. BAR REINFORCING STEEL.
LUMP. STRUCTURAL STEEL.
6.800 M.B.M. BRIDGE TIMBER TREATED 16 LBS.
2680 LIN. FT. TIMBER PILING TREATED 16 LBS.
70 CU. YDS. EXCAVATION Nº 1.
15 CU. YDS. EXCAVATION Nº 2 (IF REQUIRED).
4600 CU. YDS. CHANNEL EXCAVATION.
400 SQ. YDS. PLAIN RIPRAP.
0.826 ACRES. CLEARING & GRUBBING.
2 TEST PILES.

DRAWN B.D. 3-24-34
TRACED B.D. 3-26-34
CHECKED B.L.G. 3-24-34
REVIEWED C.A.M. 3-27-34

STATE HIGHWAY BOARD OF GEORG
BRIDGE DEPARTMENT

PLAN AND ELEVATION
BRIDGE OVER SUWANEE CREE
STA. 493+25 TO STA. 496+8
GWINNETT CO. F.A.P. NRS. 49
SCALE: 1" = 20'-0" MARCH 19

water surface and stream bed. Alignment and grade of the stream, structure,and roadway approaches should be determined,as well as the angle of skew - which is the smaller angle between the highway center line and the face of the abutment. Similar measurements should be made on any nearby structure.

Every effort should be made to obtain depths and types of footings,character of foundation and abutment walls;and if on pile bents,the condition of bents should be stated with a sketch showing span lengths,number and spacing of piles accurately determined. The general condition and appearance of the existing structure should also be noted.

Figure XII shows a typical Plan and Elevation sheet of a bridge,giving all essential data,to accompany a set of roadway or bridge plans.

RAILROAD GRADE SEPARATIONS

Insofar as profile,plan,and soundings for foundations are concerned,the information required for a structure either over or under a railroad is essentially the same as that required for a bridge across a stream. The survey should include cross-sections of the railroad cut or embankment and the adjacent ground.

In addition,the railroad should be accurately located. All sidings,signal towers,and both frog and switch points of any switches close to the survey should be shown. If the railroad is on a curve,the degree of curve and the approximate location of the P.C. and P.T.,if close to the survey,should be determined. All important dimemsions as: Station-plus of railroad center line; angle between survey and railroad (measured from curve tangent if either is curved) after being carefully checked; and perpindicular distance between tracks,if there is more than one track; should be given.

Measurements should be taken to the nearest railroad mile-post,and its number,distance and direction from highway center line noted;as: North,M.P.#81,2898'. The name of the railroad station in each direction should also be noted. All railroad structures adjacent to the proposed crossing,such as pipes, culverts,section and tool houses,semaphore signals,poles and wire lines,and switch lights,should be located and shown in the notes. The elevation of the top of each rail at the point crossed by the survey,and for a distance on each side of the highway center line,sufficient to determine grade,should be taken. Information on the use of existing and probable future tracks should be secured when possible;and all utilities,as water mains,pole lines, etc.,within the area to be occupied by the proposed bridge noted.

In the case of an overhead crossing,where the railroad is in a cut,the material in the bank should be carefully examined and soundings taken. These soundings should be taken far enough back to be beyond any probable abutment location.

In the case of an underpass,attention should be given to the important question of drainage,noting particularly the elevation and location of the lowest practical outlet. If the underpass is near a stream it should be located and elevations taken in the stream bed at various points,and at any high water mark. Should there be a railroad drainage structure nearby,its location and the elevations of inlet and outlet carefully shown.

Careful examination and inquiry should be made relative to the backing up caused by the railroad structure that would likely force the water to run thru the underpass. In case of backing up,the feasibility of placing an auxiliary culvert under or beside the underpass should be reported on. If there is back water from a large stream,its maximum and average elevation should be determined.

Information relative to a temporary or detour crossing while structure is under construction should be included in notes if at or near site of proposed crossing.

O F F I C E   P R O C E D U R E

STATE AID PROJ. No.	FED. ROAD DIST. No.	STATE	FED. AID PROJ. No.	FISCAL YEAR	SHEET No.
	8	GA.	496 D	34	1

N.R.S.

INDEX

SHEET No.	DESCRIPTION
1	Cover
2	Typical Section & Summary
3	Detailed Estimate
4-13	Plan and Profile
14-16	Earthwork Overhaul Mass Diagram
17	Plan & Elevation Suwanee Creek Bridge
18	Ga. Std. No. 1001 Conc. Hdwls
19	" " " 2302 Conc Box Culvts
20	" " " 2303 " " "
21	" " " 2304 " " "
22	" " " 2305 " " "
23	" " " 2306 " " "
24	" " " 2307 " " "
25	" " " 2308 " " "
26	" " " 3842 Detail of Bridge
27	" " " 9003 F.A.P. Markers
28	" " " 9005 Superel of Curves & R/W Markers
29	" " " 9012 Stone Ditch Checks
30-34	Cross Sections Drainage Structures
35-88	Cross Sections Earthwork

STATE OF GEORGIA
STATE HIGHWAY DEPARTMENT OF GEORGIA

PLAN AND PROFILE OF PROPOSED
STATE HIGHWAY

FEDERAL AID PROJECT
NRS 496-D

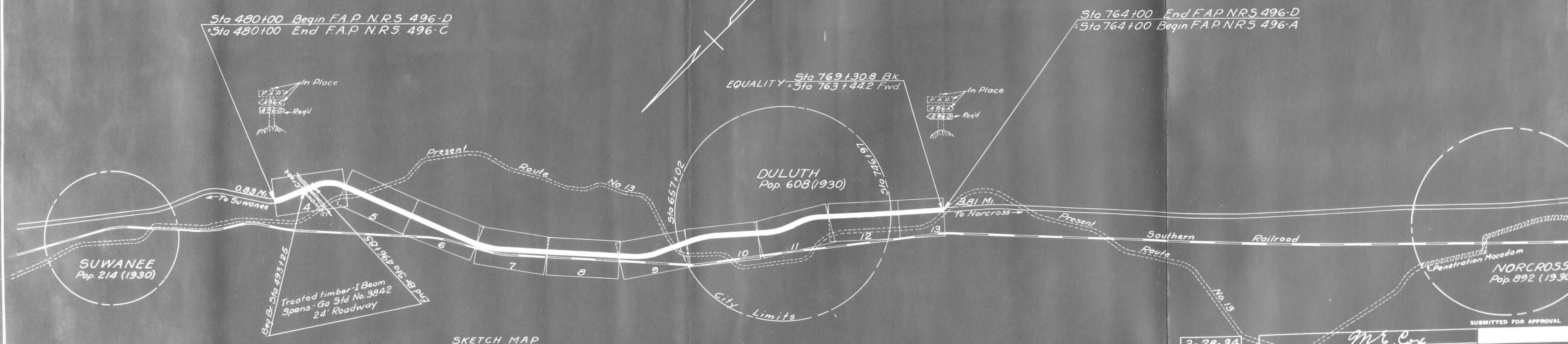
GWINNETT COUNTY
BUFORD-ATLANTA-ROAD

FEDERAL ROUTE #
STATE ROUTE # 13

SCALES { PLAN 1 IN.=100 FT.
PROFILE, HOR., 1 IN.=100 FT., VERT., 1 IN.=10 FT.

CONVENTIONAL SIGNS

- STATE AND NATIONAL LINE
- COUNTY LINE
- CITY, VILLAGE OR BOROUGH
- TOWNSHIP LINE / SECTION LINE / GRANT LINE
- FENCE LINE / GUARD RAIL
- UNFENCED PROPERTY
- RIGHT OF WAY LINE
- TRAVELED WAY
- RAILROADS
- RETAINING WALL
- BASE OR SURVEY LINE
- LEVEE
- CULVERTS
- DROP INLET
- TROLLEY POLE
- POWER POLE
- TELEPHONE OR TELEGRAPH POLE
- MARSH
- HEDGE
- GROUND ELEVATION
- GRADE ELEVATION
- RIGHT OF WAY MARKER
- F. A. P. MARKER



3-28-34
DATE

M. E. Cox
STATE HIGHWAY ENGINEER OF GEORGIA

SUBMITTED FOR APPROVAL

STATE HIGHWAY ENGINEER - OF G

CHAIRMAN - STATE HIGHWAY DEPART

RECOMMENDED FOR APPROVAL

DISTRICT ENGINEER - BUREAU OF PU

RECOMMENDED FOR APPROVAL

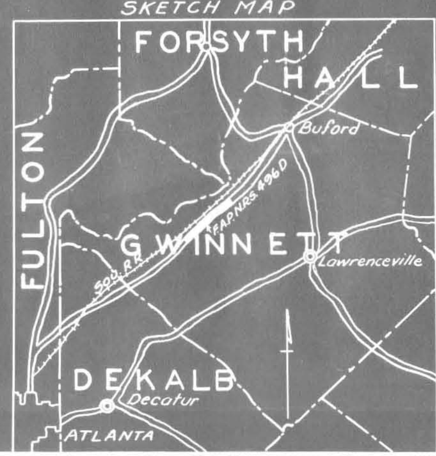
CHIEF ENGINEER - BUREAU OF PUBLI

APPROVED

DIRECTOR - BUREAU OF PUBLIC ROAD

Date Plans Completed March 28, 1934

SKETCH MAP



LAYOUT
Scale ~ 1" = 2000'

Net Length Roadway	= 28,626.6 Lin. Ft.	= 5.421 Mi.	
Net Length Bridges	= 360.0 "	" = 0.068 "	
Net Length Project	= 28,986.6 "	" = 5.489 "	
Net Length Exceptions	= 0.0 "	" = 0.0 "	
Gross Length Project	= 28,986.6 "	" = 5.489 "	

NOTE: ALL WORK TO BE DONE IN ACCORDANCE WITH THE STANDARD SPECIFICATIONS OF THE STATE HIGHWAY DEPARTMENT OF GEORGIA, DATED DECEMBER 10 1933, & APPROVED BY BUREAU OF ROADS, AND REVISIONS SUBMITTED FOR PROJECT

F.A.P.-N.R.S. 496-D

OFFICE PROCEDURE

Upon receiving the field notes in the office they are first thoroughly checked and then plotted on standard plan sheets, as illustrated by Figures X to XIV.

After the alignment and level notes are plotted the grades,based on tentative grades on continuous profile,are laid, and earthwork quantities calculated and balanced. All curves and grades should be based upon requirements previously mentioned.

Drainage structures are determined,based upon field recommendations and office determination of drainage areas,and shown on the plan-profile sheet. All bridge structures required are turned over to the Bridge Department for design.

After plans have been completed sufficiently to show all grades and recommended drainage structures,they are usually returned to the field for a preliminary inspection(P.S.& E.)by the State Highway Engineer,or assistant,the Division Engineer and, if a Federal project,the representative of the Bureau of Public Roads. They will note any changes or corrections required on the plans and return them to the office where they will be completed.

When the plans are completed a Summary Sheet,Fig.XIV, will be drawn up listing all the quantities required to construct the road.

A cover or title sheet will also be drawn up showing the entire line,and major stream and road crossings. Fig.XIII illustrates such a sheet,and it is interesting to note,in this case,how the Locating Engineer located this road so as to eliminate grade crossings and obtain a shorter and straighter alignment.

Thus all the information required to stake out and

bu

TYPICAL SECTION AND SUMMARY OF QUANTITIES

FED. ROAD DIST. No.	STATE	FED. AID PROJ. No.	FISCAL YEAR
8	GA	496 C	34

PIPE CULVERTS

Station	Cross Drains 18"	Cross Drains 24"	Cross Drains 30"	Cross Drains H'w'ls	Cross Drains Std.	Class "B" Concrete	Side Drains 15"	Side Drains 18"	Side Drains 24"		
[illegible]	55			13'x10'	1001	2.10					
[illegible]	55			13'x10'	1001	2.10					
[illegible]		41		13'x10'	1001	3.20				6	15
[illegible]		40		13'x10'	1001	3.20				6	15
[illegible]							30				
[illegible]							30				
[illegible]			60	13'x10'	1001	4.65				6	15
[illegible]			39	13'x10'	1001	3.92				6	15
[illegible]		46		13'x10'	1001	3.17				12	15
[illegible]			57	13'x10'	1001	4.65				6	15
[illegible]							20				
[illegible]			39	13'x10'	1001	3.92				6	15
[illegible]	36			13'x10'	1001	4.66					
[illegible]	67			13'x10'	1001	1.80					
[illegible]		161		13'x10'	1001	3.20				6	15
[illegible]	53			13'x10'	1001	2.30					
[illegible]		55		13'x10'	1001	3.20				6	15
[illegible]							40				
[illegible]	55			13'x10'	1001	2.30					
[illegible]			58	13'x10'	1001	4.66				6	15
[illegible]						2.71				6	15
[illegible]		69		13'x10'	1001	2.71				6	15
[illegible]		55		13'x10'	1001	2.71				6	15
[illegible]		55		13'x10'	1001	2.68				12	15
Total	387	387	289			82.30	130			126	255

* - Cast Iron Pipe (12x14) = 146'

In general the governing slope on fills shall be 2 to 1 exception to be made on high fills over 30 ft or long distance where 2 to 1 slope is more economical in which case a slope of 1½ to 1 will be used.

TYPICAL GRADING SECTION

6' — 16' — ℄ — 16' — 6'

2 to 1 Slope

Subgrade Varies as shown on Cross Sections

Crown 6" in 16'

Profile grade except at Curves. See Ga. Std. 3005

Scale 1" = 20'

3 to 1 Slope

Roadway to be graded with flat subgrade and crowned with road machine as shown by the dotted line. The work of machining and shaping the roadway to the crowned shape is to be done by the grading contractor without additional compensation.

Select Material is to be placed 5"x20' loose, where directed by Engineer.

Wherever Selected Material is used the work of machining the roadway to the crowned shape is to be done after the Select Material has been placed.

Basis of payment: Select Material Cu. Yd., ½ Mile Free Haul and ½ Mile Overhaul Units.

SURFACING QUANTITIES

Select Material	Cu. Yds.	8855
O.H. on Select Material	Unit Yds.	2000

GUARD RAIL

Total

Standard

RIGHT OF WAY MARKERS

Total 46 — Ga. Std.

GRASSING SLOPES

Total 50,000

RIP RAP

Total

BRIDGE QUANTITIES

Bridge over Suwanee Creek — Sta. 438+25 to Sta. 4[illegible]

255 Cu. Yds. Class "A" Concrete

[illegible] Cu. Yds. Class "B" Concrete

[illegible] Lbs. Bar Reinforcing Steel

[illegible]

[illegible] Lin. Ft. Hand Rail

[illegible] Cu. Yds. [illegible] Excavation

[illegible] Clearing & Grubbing

[illegible] Test Piles

F.A.P. MARKERS

Posts	= 0	Ga. Std.
Plates	= 0	No. 3003
Arrows	= 2	

EARTH WORK QUANTITIES

Sheet No.	Common	Select Material	Borrow	Waste	Emb.	Ditch Exc.	Channel Exc.	Overhaul Sta. Yards
0-4	28125				23539	312	1000	59255
5	12610	600	206		12190	528	200	525
6	2661	20			9435	328	300	
7	14886		167		17906	436	660	
8	13810	40			13987	496	300	
9	12411	2700			14525	606	100	68
10	17620	2000	338		20323	354	100	
11	29623	100			29265	613	400	6910
12	10597	900	30		12911	553	200	
* 13	1760	400	327		2730	353	50	117
Total	159803	6160	1106		160319	5003	3310	66575

O-530 Cu. Yds. (Com.) hauled back to F.A.P. No. 496-C and paid for on F.A.P. 496-C

* 1730 Cu. Yds. (Com.) hauled forward to F.A.P. No. 496 A and paid for on F.A.P. 496 A

GENERAL NOTES

Ditches to be widened to R/W when necessary to obtain borrow.

All borrow pits are to be thoroughly drained.

All obstructions to be moved to clear R/W lines by County.

All telephone, telegraph and power poles to be moved to clear R/W lines by County except on city streets where poles are to be moved to clear construction lines a minimum distance of 20' from ℄.

LOCAL STONE DITCH CHECKS

GA. STD. No. 9012

[illegible] = 393.3 Cu. Yds.

TYPICAL SECTION INLET-OUTLET CHANNEL CHANGE AND DRAINAGE DITCH EXCAVATION

Material from ditches to be [illegible]

CLEARING AND GRUBBING

Sheet No.	Station to Station	Sq. Ft.
	Actual Clearing and Grubbing	
	Additional C & G for full width of R/W	
	C & G for full width of R/W	
	Clearing and Grubbing outside R/W	

SPECIAL NOTE

The work of preparing subgrade shall be done in accordance with Section 17 of the Standard Specifications and the cost shall be included in the price bid for paving. Any dirt excavated from subgrade and not used within the limits of the subgrade shall be disposed of as directed by the engineer without additional compensation. All dirt removed, whether used for constructing shoulders, filling washes or flushing outfalls, with the exception of that moved in preparing subgrade in accordance with Section 19 of the Standard Specifications, will be paid for on a Cu. Yd. basis as common and borrow excavation and material necessary for this work will be obtained as directed by the engineer, from widening and lowering side ditches. Overhaul will be allowed on all pay excavation hauled over 1,000 ft.

NOTE:
The Roadway and Pavement on all Curves One Degree and over shall be superelevated and widened on Curves Six Degrees and over, according to Georgia Standard number 9095. Revised Nov., 1931.

NOTE:
If the Material that is to be used in the last foot of fill is found, by the Resident Engineer, to be unsatisfactory as a base for the Surfacing, to be used, it shall be wasted, and suitable material obtained. Payment will be made for both waste and borrow, at the bid price for that class of Excav.

CONCRETE BOX CULVERTS

Station	Size	Length	Standard	Design	Skew	Class "A" Concrete	Reinforcing Steel
Total						657.17	54,421

LENGTH OF PROJECT

Station to Station	Lineal Feet Roadway	Lineal Feet Bridges	Equalities and Exceptions
[illegible]	1925		
[illegible]		360	
[illegible]	27203.8		
Net Length Roadway	29128.8		5.421 Miles
Bridges		360	0.068
Project	29488.8		5.489
Exceptions	0.0		0.000
Gross Length Project			5.489

Recommended: Division Engineer

Recommended: Office Engineer

Approved: State Highway Engineer

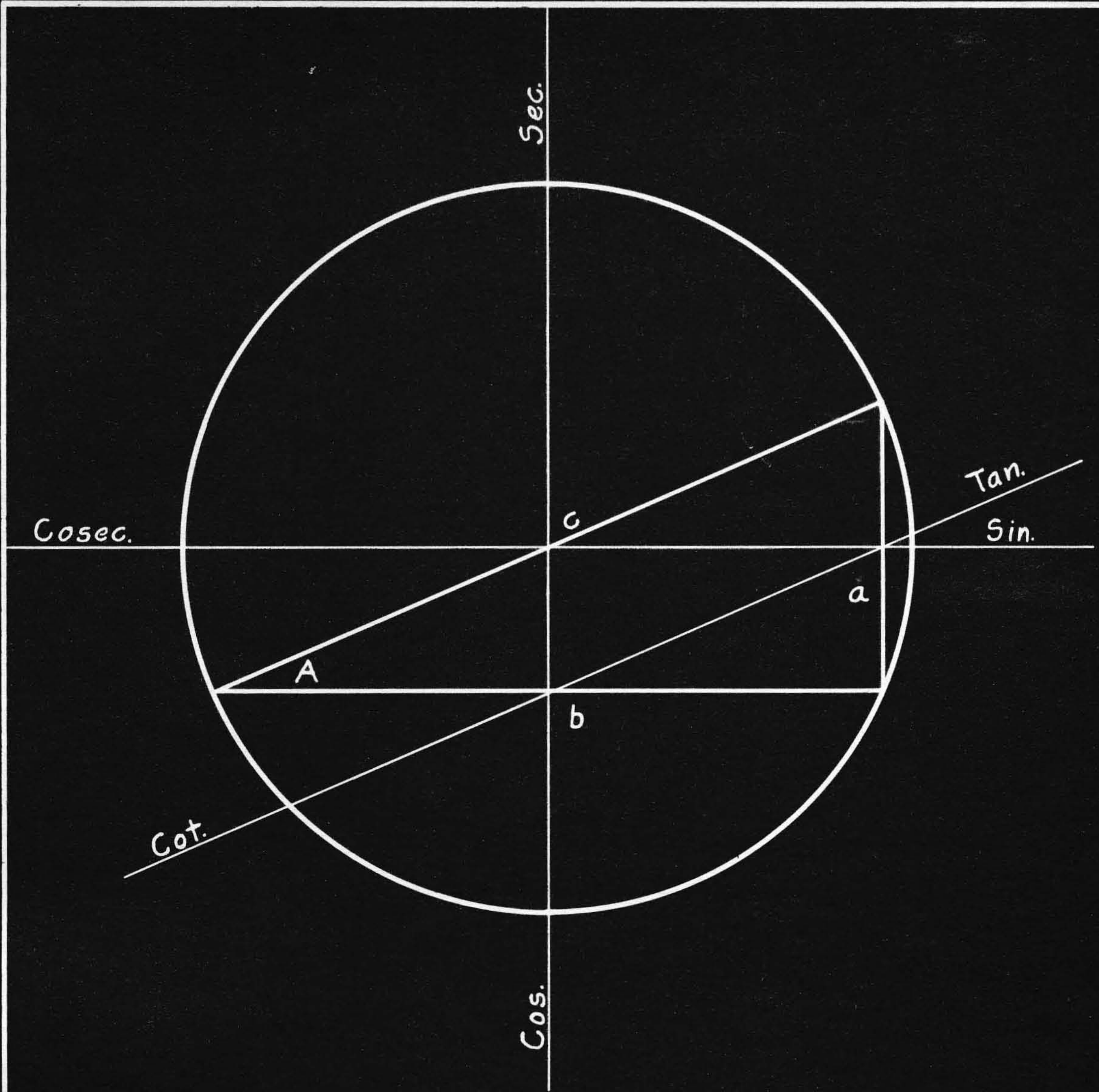
PLATE 3—CROSS SECTION G. P. R. & R. E. STANDARD

KEUFFEL & ESSER CO. NEW YORK.

build a road and its drainage structures will be found in a completed set of roadway plans.

Any recommendations for changes of grades or alignment during construction are also noted on these plans.

After a job has been completed the Resident Engineer in charge must note any variation from the plans,during construction,on them in red ink and submit it with his final estimate as a permanent record of the road as actually constructed.



Function of Angle, shown on line, equals first letter, on line considered, divided by second letter on same line. For instance Sin. A = a/c where "a" equals first letter and "c" is second letter on same line, or Cosec. = c/a when "c" is first letter and "a" is second letter.

CHART FOR DETERMINING TRIGONOMETRIC FUNCTIONS

PLATE 9

C O N C L U S I O N S

CONCLUSIONS

From the preceeding discussion we find that a highway location is made for the purpose of (1) Building an entirely new highway to serve a distinct traffic need,which may be the result of some local improvement or of traffic density,on existing routes,or of political expediency; (2) relocating existing routes to facilitate traffic movement or to reduce traffic costs by elimination of excessive grades,curvature or grade crossings, and by shortening of distance;and (3) for the purpose of safety by eliminating dangerous and hazardous points on an existing road.

One can readily see that a knowledge of the facts given are of extreme importance to those Engineers charged with the planning and location of our highways. Theirs is the duty to build a safe road at a minimum of cost,in order to amply serve the locality,and purpose,for which built by carrying the maximum traffic at a minimum expense.

Since it is impossible to give the actual mental process of the Locating Engineer,as he goes about fitting the road to the terrain,an attempt has been made to state all essential facts which he must keep in mind and consider before reaching the final decision. Examples have been given of actual locations which it is hoped have illustrated these essentials.

The mechanics of the survey are not difficult and easily mastered,but the mental processes that must be gone thru and mastered come only from years of experience. Thus it is hoped that realization of the principles and economics involved will show that an engineer must give some thought to his problem before a road can be correctly located,and that it is not so easy as to lead one to believe that a road might be located by taking an instrument in the field and turning off a few angles.

We find also that the need for the proper planning of a state system is essential if roads are to be built to carry future traffic in safety,and at a minimum expense to the traveling public. Unless this is done the State will be put to tremendous expense to correct future traffic evils,and in most cases will be able to alleveiate,only,rather than correct the evil. Money spent now on proper planning and location will result in future savings measured not only in money,but in human happiness and lives as well.

Our present inadequate road systems well illustrate the need for study on the part of our responsible authorities, and the necessity of our engineers devoting the same time and thought to the problems of location as they do to the other problems of road building.

It is no longer possible to restrict the motor vehicle to our roads - the roads of the future must be so located, designed,and built as to take care of any traffic to which they might be subjected. When this is accomplished the economic well being of our communities will be increased,and the toll of lives lost,due to negligence and faulty location,reduced to the minimum.

FIG.XV

Bridge on Richmond-Washington Highway (U.S.1)
between Alexandria and Fredricksburg, Va.
Note excellent alignment and sight.

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